Dairy Herd and Barns at Iowa State College.

Frontispiece.

THE FEEDING OF DAIRY CATTLE

BY

ANDREW C. McCANDLISH, M.S.A.

Professor of Dairy Husbandry, Iowa State College of Agriculture and Mechanic Arts

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Imp. Jewel's Guernsey Lily

DEDICATED

TO

THE COW WITH THE
CRUMPLED HORN

PREFACE

THE art and science of feeding dairy cattle has ever been changing, and during the last two decades greater improvements have been brought about in this branch of agriculture, by practical feeders and investigators, than ever before. The importance of the dairy cow as an economic factor is now recognized. This is primarily due to the fact that, with little waste of energy, she converts the roughages and other feeds grown on the farm into products suitable for human consumption.

In making this presentation of the feeding problem the aim has been to render the work broad enough to be of aid to the student. For this purpose the earlier sections contain a brief résumé of material which belongs to the field of nutrition rather than to that of feeding. It is hoped that this will render it possible for the student to link up his work on feeding dairy cattle with the training he has previously received in nutrition. At the same time it is hoped that the man interested in feeding, but with little foundation in nutrition, may obtain some information of value from the earlier part of the work. To put it briefly, the main object in view has been to review, in a non-technical manner, the main principles on which the feeding of dairy cattle is founded and then discuss the problems of practical feeding.

Much of the technical information included has been obtained from Government and State Experiment Station

publications, but as this is not intended to be a reference work, direct mention of these could not always be made. The remaining material consists of information obtained in the practical management of a herd and from many feeders, as well as from experience gained while connected with the practical and investigational work of the Dairy Husbandry Department of Iowa State College, during the past eight years.

All of the illustrations are taken from the Iowa State College herd, and the writer wishes to express his thanks to Dean C. F. Curtiss for permission to use these. The author also wishes to express his appreciation of the advice received from Professor H. H. Kildee; of the excellent suggestions received from Professor E. Weaver, who read the manuscript; and of the valuable editorial aid given by Professor F. W. Beckman.

ANDREW C. MCCANDLISH.

IOWA STATE COLLEGE, AMES, IOWA.
September, 1921

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PART I

THE FUNDAMENTAL PRINCIPLES OF DAIRYING

THE FEEDING OF DAIRY CATTLE

CHAPTER I

THE INDIVIDUAL COW AS THE UNIT IN PROFITABLE DAIRYING

A STUDY of any herd of cows, unless they have been very carefully selected, will show that in addition to wide differences in conformational characteristics there are large individual variations not only in total milk and butter fat production but also in economy of production. The aim of the dairyman is to obtain a herd of cows combining conformational excellence with economical production and, as the causes of the large individual variations which occur in production are fundamental, they must be given consideration before the feeding problem can be studied in a satisfactory manner.

BREEDING

It is frequently stated that the breeding of a cow is very largely responsible for her inherent ability to produce milk and butterfat. That this is true to a very considerable degree has been shown in a breeding experiment at Iowa State

College. Scrub cows of no known breeding and of very low producing ability were mated to pure-bred bulls of the Guernsey, Holstein and Jersey breeds and each heifer resulting from such a mating was bred back to a bull of the same breed as her sire. Records are now available on two generations of grades descended from the original scrub cows of the experiment and it has been found that the first generation grades produced on the average 39 per cent more milk and 38 per cent more fat than their scrub dams, while the increases in the case of the second generation grades, as compared with the scrubs, was 117 per cent in milk and 105 per cent in butter fat.

This shows the influence breeding has on production, and demonstrates that the use of good bulls can do much to increase production, as the yield of butter fat was raised from an average of 185.18 pounds per year in the case of the scrubs to 379.31 pounds per year in the case of the second generation of grades.

TABLE I

AVERAGE PRODUCTION OF TWO GENERATIONS OF GRADES AND THEIR SCRUB ANCESTORS

Group	Dams		Daughters		Grand-daughters	
	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds
Holstein	3673.8	167.36	6697.3	277.27	10,209.2	398.63
Guernsey	4158.6	190.77	4786.4	237.22	7,426.7	380.16
Jersey	4046.7	193.01	4933.4	265.88	5,659.4	298.94
Average	3912.3	185.18	5492.5	266.69	8,507.0	379.31

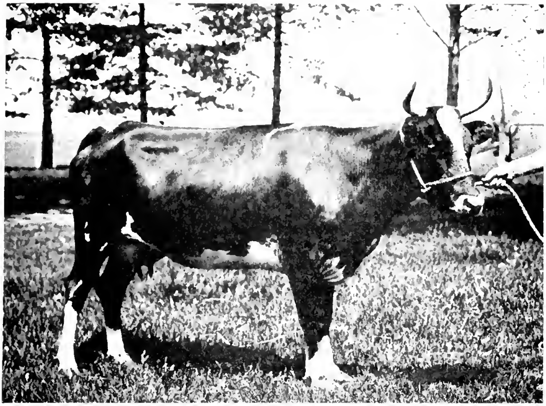

Fig. I.—Scrub Cow No. 60, Average Production 3313.2 Pounds of Milk and 178.47 Pounds of Fat.

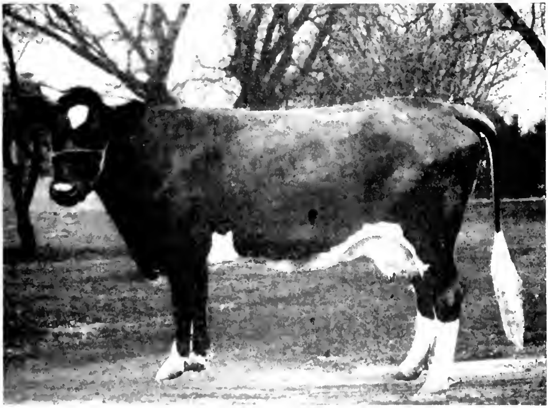

Fig. II.—Half-blood Holstein Cow No. 207, Out of Scrub No. 60. Average Production 6306.2 Pounds of Milk and 287.74 Pounds of Fat.

Fig. III.—Three-quarter-blood Holstein Cow No. 311, Out of Half-blood Holstein No. 207. Average Production 10,428.3 Pounds of Milk and 460.73 Pounds of Fat.

TABLE II

Average Increase in Production of Two Generations of Grades Over Their Scrub Ancestors

Group	Increase in Production Over Scrub Ancestors			
	First Generation		Second Generation	
	Milk, Per Cent	Fat, Per Cent	Milk, Per Cent	Fat, Per Cent
Guernsey	15	24	79	99
Holstein	82	65	178	138
Jersey	22	37	40	54
Average	40	44	117	105

Since breeding is an important factor in determining production, great care must be taken in the selection of breeding herds, and this is especially true in the case of the bulls to be used. No herd of cows should be headed by anything but a pure-bred bull, and some pure-bred bulls are not good enough to head even a scrub herd.

TABLE III

A Comparison of Two Guernsey Bulls

Bulls	Average Records of Dams		Average Records of Daughters		Increase in Production Over Dams	
	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
"Fullwood Hopeful" . . .	3885.2	169.99	4045.1	172.58	4	2
Imp. Rouge II's Son. . . .	4295.6	194.05	5360.1	275.81	25	43

The two pure-bred Guernsey bulls, "Fullwood Hopeful" and Imp. Rouge II's Son, were used in the breeding work just mentioned, and although they were both of excellent breeding the results they produced were very different. The daughters of "Fullwood Hopeful" produced only 4 per cent more milk and 2 per cent more butter fat than their dams, so that this bull can be considered useless; while Imp. Rouge II's Son sired heifers producing on the average 25 per cent more milk and 43 per cent more fat than their dams. This emphasizes the importance of care in the selection of a herd sire.

SELECTION

Though breeding has a profound influence on production, it must be remembered that even when the ancestry of a cow is definitely known her ability to produce milk and butter fat

cannot be accurately foretold. This is very clearly demonstrated by the case of two grade Guernsey cows in the Iowa State College experimental herd. These cows were sired by the pure-bred Guernsey bull, Imp. Rouge II's Son, and were out of a scrub cow of no known breeding.

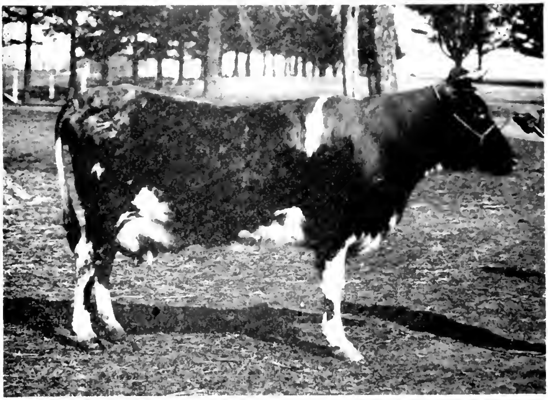

FIG. IV.—Scrub Cow No. 53. Average Production 5258.7 Pounds of Milk and 233.63 Pounds of Fat.

TABLE IV

PRODUCTION OF A SCRUB COW AND HER TWO GRADE DAUGHTERS

Cow	Average Production		Increase in Production Over Dam	
	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
Scrub No. 53	5258.0	233.60		
Grade No. 180	3639.0	180.53	−31	−23
Grade No. 253	6128.4	298.33	17	28

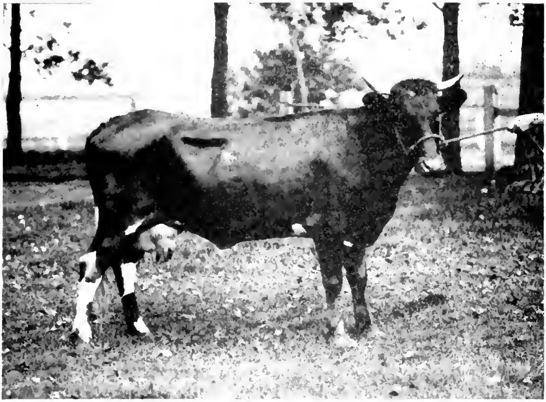

Fig. V.—Half-blood Guernsey Cow No. 180, Out of Scrub No. 53. Average Production 3641.5 Pounds of Milk and 180.53 Pounds of Fat.

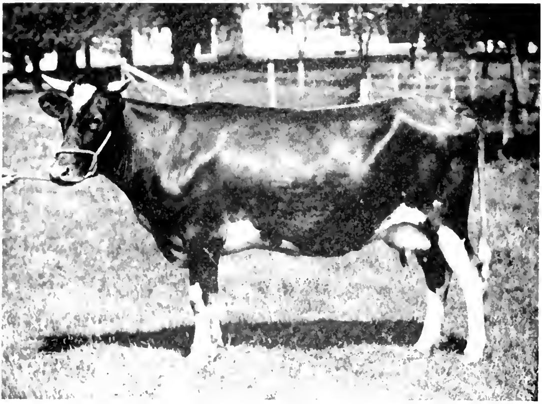

Fig. VI.—Half-blood Guernsey Cow No. 253, Out of Scrub No. 53 and Full Sister to Half-blood Guernsey No. 180. Average Production 6168.2 Pounds of Milk and 306.40 Pounds of Fat.

The two animals, No. 180 and No. 253, though full sisters, varied widely in producing ability, No. 180 producing 31 per cent less milk and 23 per cent less fat than her scrub dam, while No. 253 produced 17 per cent more milk and 28 per cent more fat than did her dam. This is a wide variation in production and might be attributed to the fact that the dam of the cows being considered was a scrub and consequently would tend to produce daughters of doubtful producing ability.

It is true that the results obtained in the mating of scrubs are more doubtful and vary more than those obtained where pure breds which have been carefully selected for generations are concerned; but similar results are obtained, though less frequently, with pure-bred animals.

TABLE V

PRODUCTION OF A PURE-BRED GUERNSEY COW AND HER DAUGHTERS

Cow No.	Average Production		Increase in Production Over Dam	
	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
98	7258.7	204.87		
225	6213.0	204.16	−14	0
267	9772.8	473.38	35	61

Here the same wide difference in producing ability between the two pure-bred cows, Nos. 225 and 267, even though they were full sisters sired by Imp. Rouge II's Son, is noticed as was found in the case of the grades. But this might be attributed to the bull used; another pure-bred bull may therefore be considered.

He is the Jersey bull, Pogis 80th of Hood Farm, and he sired two heifers out of a pure-bred Jersey cow, No. 127 in the Iowa State College herd.

TABLE VI

Production of a Pure-bred Jersey Cow and Her Daughters

Cow No.	Average Production		Increase in Production Over Dam	
	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
127	8190.5	382.92		
194	3345.3	175.68	−59	−54
223	7837.6	419.89	− 4	10

Here it is seen that in one case the production of the heifer was above that of her dam, while in the other case there was a very marked difference, and in both cases the milk yield for the heifers was lower than for their dam. This clearly shows that there are wide individual differences in the producing ability of animals of the same breeding.

Where a consistent system of breeding has been pursued for some time the chances of a decrease in production with each succeeding generation are less, but at the same time it should be remembered that when a high level of production has been reached in a herd it is more difficult to increase the average production than it is in the case of a poor herd. Rigid selection of the sires is needed in such cases, as is clearly demonstrated by a comparison of two Jersey bulls used at Iowa State College.

Fox's Lad o' Dreamwold was a detriment to the herd, as his daughters produced 18 per cent less fat than their dams,

while Pogis 80th of Hood Farm increased the average production of the herd by 12 per cent in fat yield.

TABLE VII

COMPARISON OF PURE-BRED DAUGHTERS OF TWO JERSEY BULLS

Bulls	Average Production of Dams		Average Production of Daughters		Increase in Production Over Dams	
	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
Fox's Lad o' Dreamwold.	7667.9	356.30	6005.0	290.84	−22	−18
Pogis 80th of Hood Farm	7280.4	343.25	7300.2	385.92	0	12

In breeding, and especially in the case of pure-bred animals, the problem of "nicking" must be given consideration. Some animals, even when capable of producing good offspring, will not give good results even when mated with individuals that are also good. This is most frequently found in the case of pure breds of dissimilar breeding, while good animals of similar breeding will generally "nick" well and give good results.

This lesson can again be clearly shown from the breeding record of the Guernsey bull, Imp. Rouge II's Son. In studying these records it is found that Imp. Rouge II's Son was mated to two cows with average records below three hundred pounds of fat per year and three cows with an average production over this amount. It is found that the daughters of the high-producing cows were in every case poorer producers than their dams, and at first sight this might condemn the bull as being unfit to mate with cows of this producing ability. However, when the other individuals

are studied it is evident that the daughters of the poor producers were not only better than their dams but also better than either the daughters of the good producers or the good producers themselves. From this it is evident that the bull under consideration "nicked" well with some of the cows but did not "nick" with the others. In selecting a breeding herd it is difficult to tell whether or not the sire desired will "nick" with the foundation cows; however, attention to the results that have been obtained with animals of similar breeding will frequently be of great value as a guide in the selection of the herd sire.

TABLE VIII

"Nicking" as Demonstrated in the Case of Imp. Rouge II's Son

Average Production of Dams			Average Production of Daughters			Increase in Production Over Dams	
Cow No.	Milk, Pounds	Fat, Pounds	Cow No.	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
97	5288.9	229.42	247	8385.4	400.58	57	75
			286	8309.3	394.74	57	73
			322	8908.5	470.70	68	105
98	7258.7	294.87	225	6213.0	294.16	−14	0
			267	9772.8	473.38	35	61
Average...	6305.5	264.27	....	8019.2	388.42	27	47
123	6326.9	322.22	292	5546.8	271.79	−12	−16
186	6854.9	312.41	254	5264.5	282.71	−23	−10
187	8328.7	365.19	226	6650.3	335.46	−20	− 8
Average...	7303.6	336.14	....	5875.3	301.62	−20	−10
Grand Average.	6631.0	286.98	....	7253.5	357.43	9	25

The breeding of a cow determines, to a very considerable extent, her producing ability, but it must be remembered that for best results the breeding stock must be carefully selected. Then some level of production should be aimed at, and individuals failing to come up to this should be disposed of, as there will always be a few culls produced even in a well-bred herd, though the number will be fewer than in a herd of scrubs or grades. It is only by disposing of such cows that the production of a herd can be increased or even maintained at a definite level. The individual cow is the most important factor in profitable dairying and only good producing cows should be maintained.

CHAPTER II

THE IMPORTANCE OF FEEDING

A GOOD cow is essential for profitable milk production, but before the cow can work efficiently, her needs for the materials from which milk is produced must be met. The cow produces milk; but she must be supplied with the raw materials, in the form of feed, from which the milk is produced. The individual cow is the most important factor to be considered by the dairyman, and ranking closely to this problem is the consideration of feeding.

LIBERAL FEEDING ESSENTIAL

Feeding costs money; and too many endeavor to reduce the cost of milk production by stinting the feed of their cows. This is not good economy, as without the feed the cows cannot produce the milk, and the lower the milk and butter fat yield the greater the cost of production per unit of product, as a general rule.

The economy of liberal feeding has been clearly pointed out in the work conducted at Iowa State College with the scrub cows already mentioned, and the advantages of such a system are clearly seen from the records of two cows that reached the Station when they were four years of age.

The scrub cows had been subject to very poor care and had rustled most of their feed, but when they were given good feed and care in the College Herd they increased in production from their first year. Unfortunately, no records are available

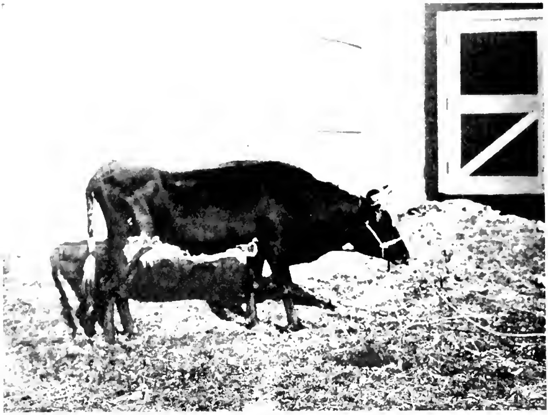

FIG. VII.—Scrub Cow. No. 6 on Arrival at Iowa State College at 4 Years of Age. Annual Production 2886.4 Pounds of Milk and 137.94 Pounds of Fat.

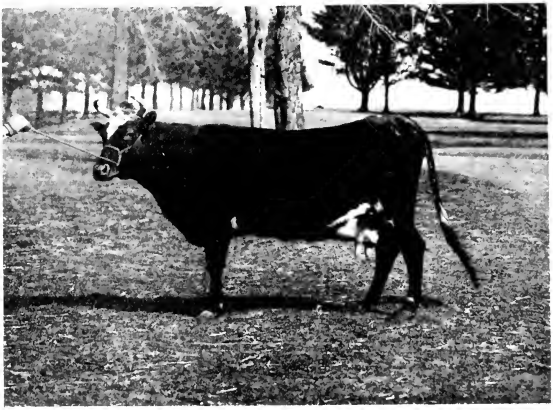

FIG. VIII.—Scrub Cow No. 6 at 7 Years of Age. Annual Production 5468.7 Pounds of Milk and 244.79 Pounds of Fat.

as to the milk and butter fat they produced under their former conditions. In their fourth lactation at the Station they were producing, on the average, 4907.7 pounds of milk and 229.91 pounds of fat, or 59 per cent more milk and 54 per cent more fat than during their first lactation period. It is known

TABLE IX

AVERAGE PRODUCTION OF SCRUBS PUT ON GOOD FEED AT FOUR YEARS OF AGE

Lactation No.	Age, Years	Average Production		Increase in Production Over First Lactation	
		Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
1	4	3084.6	149.24		
2	5	3984.4	178.97	29	19
3	6	4618.1	217.79	50	46
4	7	4907.7	229.91	59	54
5	8	4224.0	197.59	37	32
6	9	1991.3	84.76	−35	−43
7	10	2862.5	133.70	− 7	−10
8	11	2296.2	93.83	−26	−36

that as cows mature they increase in production, but the increase that could be attributed to the aging of the animals from four to seven years would, on the average, be only 10 per cent in milk and 8 per cent in fat. The major portion of the increase obtained in this experiment must, therefore, be attributed to feeding.

BEGINNING WITH THE YOUNG STOCK

With these four-year-old cows there were some cows past their prime and a few immature heifers. A comparison of these three groups brings out another important point.

TABLE X

COMPARISON OF SCRUBS SUBJECTED TO GOOD CONDITIONS AT DIFFERENT AGES

Group	Average Production		Increase in Production Over Mature Cows	
	Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent
Mature Cows	3168.7	153.64		
Four-year-olds	3507.7	166.36	14	8
Heifers	4036.1	191.21	27	24

In making this comparison, allowance has been made for the age at which the records were made. It is found that the cows which had been kept under poor conditions until they reached maturity and had then been subjected to good treatment had the lowest average production; those that were put under good care at four years of age were the next best; while those that had been liberally fed from the time they were calves gave the most milk and butter fat, or 27 per cent more milk and 24 per cent more fat than was produced by the group kept under poor conditions till maturity was reached.

Liberal feeding during the lactation period of a cow is essential, but just as important is the feeding of the dry stock and especially the growing heifers. If heifer calves that are being grown out to take their places in the herd are

poorly fed, they can not give the best results when they come to producing age. The potential dairy cow must be liberally fed from birth.

NECESSITY OF INDIVIDUAL FEEDING

The individual cow is the unit in profitable dairying, and the most important factor, in addition to the inherent ability of the cow to produce, is feeding. As a consequence, the feed requirements of each individual cow in the herd must be considered if the best results are to be obtained. The ability of the cow to produce and her feed requirements are very closely associated.

It has long been known that animals of the same or similar breeding and reared under identical conditions will not always be alike in producing ability when they reach maturity. Several illustrations of this have already been given. The reasons for this were not understood until work was conducted at the Missouri Experiment Station in an attempt to elucidate the problem.

At the outset it was recognized that this individual variation in producing ability might be due to one or more of the following factors: variation in the digestive powers of the animals; difference in the quantities of feed required for body maintenance; utilization of part of the ration for the production of body fat; difference in the amount of feed actually used in addition to that required for maintenance.

Two Jersey cows which were a little more than half sisters and of about the same age were used. Previously they had received the same treatment, though one had proved to be a much better producer than the other. A complete record of the feed consumption of the animals was kept; the rations fed were of the same composition but were varied in quantity to suit the needs of the individuals. Exact records of the yields and composition of the milk were obtained.

The animals were kept barren and at uniform weight throughout the experiment. At the period of maximum production, digestion trials were conducted, and at the end of the lactation period maintenance trials were made, the feed used being the same in composition as that used during the lactation period. The ration consisted of corn silage, alfalfa hay and a grain mixture made up of four parts ground corn, two parts wheat bran and one part oil meal; during a portion of the trial some green feed was also given.

As the animals were maintained at a uniform weight the difference in production could not have been due to the production of body fat by the inferior producer, and likewise it was found that the differences in digestive powers and maintenance requirements were too small to account for the large differences in milk and butter-fat yields.

TABLE XI

FEED CONSUMPTION AND MILK AND BUTTER FAT PRODUCTION OF TWO COWS OF VARYING PRODUCING ABILITY

Cow No.	27	62
Total production:	Pounds	Pounds
Milk	8523	3189
Fat	470	169
Total feed consumed:		
Grain	3424	1907
Hay	2904	1698
Silage	8788	5088
Green feed	4325	2102
Feed used for production:		
Grain	2223	841
Hay	1700	632
Silage	3960	796
Green feed	4325	2102

The total feed consumption of the two animals varied widely, but their maintenance requirements varied little. So when the feed needed for maintenance is deducted from the total amount consumed there is found to be a very wide difference in the amounts of feed available for productive purposes.

The ratio between the milk produced by the two cows was 1 : 2.67, and for the butter-fat production it was 1 : 2.77, which coincided very closely with the ratio between the various amounts of feed actually used for milk production. This clearly shows that the good producing cow is simply the one that uses a large amount of feed, in addition to that needed for maintenance purposes, and utilizes it for milk and butter-fat production.

The problem of the feeder, therefore, is to provide the cow with the maximum amount of feed, in addition to what she requires for other purposes. She will convert this additional amount of feed into milk and butter fat, and the greater the amount of feed used for this purpose, the more economical will be the production of the cow.

PART II

THE CHEMISTRY OF FEEDING

CHAPTER III

THE ELEMENTARY COMPOSITION OF FEEDS

In a consideration of the feeding problem, little attention is, as a rule, given to the individual elements which, in combination, form the complex compounds of the plant and animal tissues; yet the science of chemistry shows that all substances are ultimately derived from the simple chemical elements. The feeding stuffs used for farm animals are generally vegetable products, though a few animal products, such as tankage and skim milk, are utilized. These feeding stuffs consist of complex compounds, and a knowledge of the source of these compounds is of value. The animal elaborates the constituents of its body from the compounds existing in plants or animal products, but the plants used as sources of feeds must elaborate these compounds from simpler substances.

As will be noted later, the carbohydrates, fats, proteins and ash are the main constituents derived by the animal from the plant products it consumes; the first problem, therefore, is to locate the source from which the plant obtains these substances. The plant makes them from the elements and from some simpler compounds elaborated from the elements. A very large number of elements are found in plants, in the form of compounds, but only a few of them need be considered, as all of them are not essential for animal life.

CARBON

The element, carbon, which is the main constituent of coal, and in the practically pure state forms such widely different

substances as diamonds and lampblack, forms about 50 per cent of the dry matter of plants and animals. It occurs in the air as a constituent of the gas, carbon dioxide, which when present in appreciable amounts in buildings may lead to difficulties, as it is poisonous to animals.

Green plants have the power of absorbing this carbon dioxide through their leaves and other green parts, during the hours of sunlight. Then the green coloring matter, chlorophyll, which is present, deriving energy from the sunlight, converts this carbon dioxide and water into sugar which can be carried to the various organs of the plant and there used for a variety of purposes. During this process oxygen is given off by the plant. In addition, the plant roots in the soil take up water, which has many compounds in solution, among them carbonates which contain carbon.

HYDROGEN

Hydrogen occurs in the free state as one of the gases of the air, and with oxygen it forms water. The main source of hydrogen for plants is the water taken up by the roots. Some of the salts in solution in this water also contain hydrogen. Like carbon, it enters into the composition of a very large number of compounds occurring in the various tissues of plants and animals.

OXYGEN

This gaseous element is most familiar as one of the most important constituents of the atmosphere of which it forms about one-fifth. Its presence there is essential for all the higher plants and animals. It is also one of the constituents of water. The plants derive some of it from the air through their pores and also obtain a large amount of it from the water absorbed and a smaller amount from some of the compounds in solution in the water.

NITROGEN

About four-fifths of the air is nitrogen, and one group of plants, the legumes, have the ability to use this atmospheric nitrogen for their own purposes. Their powers of utilizing this nitrogen are due to the presence of bacteria in the nodules on the roots. These bacteria, which receive some of their nutrients from the legumes, with which they are combined, take the nitrogen from the air in the soil and from it form compounds which can be utilized by the legumes. Other plants do not have this power and so are dependent for their supply of nitrogen on the nitrates which are absorbed in solution by the roots. The legumes also obtain some nitrogen in this manner. Nitrogen is a characteristic constituent of the proteins of both plants and animals.

POTASSIUM

The element potassium is not known in the free state, but its compounds are common. Some of the most familiar are potassium carbonate and caustic potash. Immense deposits of potassium salts are known. Potassium salts in solution in the absorbed water form the only source of supply for plants. This holds true for all the other elements which remain to be mentioned, and which, together with potassium, form the ash or inorganic portion of the plant.

SODIUM

This element is also unknown in the free state, but some of its compounds are very well known, including sodium chloride, sodium carbonate and sodium bicarbonate, which are generally recognized as common salt, washing soda and baking soda. The salts of sodium occur in large deposits and, like those of potassium, form a large proportion of the materials in solution in sea water.

CALCIUM

Calcium is never found in the free state, but occurs in large quantities in nature as calcium carbonate in the form of limestone and chalk, while other compounds are also abundant. It is one of the most important ash constituents so far as animal nutrition is concerned, as it is a large component of bone.

MAGNESIUM

Though not found in the free state, magnesium exists in the form of many compounds which are frequently found in conjunction with those of calcium. It is not so plentiful as calcium in the ash of animals.

IRON

Iron ores are very abundant, and varying amounts of iron compounds are universally distributed throughout the soils. Only small amounts of iron are found in the free state. In addition to being found in the ash of plants and animals, iron occurs in some proteins and is quite characteristic of some of the compounds of the blood.

SULPHUR

Though most generally recognized as the yellow flowers of sulphur, this element occurs to a limited extent in the free state. Its most common occurrence is in such compounds as sulphates and sulphides, which are quite widely distributed. Sulphur is also found in some proteins, as well as in the ash of plants and animals.

PHOSPHORUS

Though widely distributed in combination in nature, phosphorus is never found free. It occurs generally in the

phosphates, which are sometimes found in large deposits. Some of the phosphates of calcium may be taken as an illustration, though many phosphates are widely distributed. Phosphorus occurs in some proteins, as well as in the ash of living organisms.

IODINE

Iodine never occurs in the free state in nature, though iodides and iodates, especially of sodium and potassium, are widely known. Iodine is best known in the crystalline form, but on being heated it forms a violet-colored vapor which crystallizes on cooling. Compounds of iodine are common in sea water and many sea weeds contain relatively large proportions of them. In other plants and in the animal body, iodine compounds occur in smaller proportions, though they have some very important, though poorly understood, functions to perform in animal metabolism.

CHLORINE

The greenish-yellow, poisonous gas, chlorine, does not occur free in nature. Many of the compounds, into the formation of which it enters, are well known, the most familiar one being common salt, or sodium chloride. Chlorine is also one of the constituents of hydrochloric acid, which plays an important role in digestion.

FLUORINE

The gas fluorine does not occur free, and its best-known compound is calcium fluoride. It appears to derive its importance from the fact that it occurs in small amounts in the enamel of the teeth.

SILICON

Silicon never occurs in the free state, but in combination it is, perhaps, with the possible exception of oxygen, the most widely distributed element. Its most common compound is silicon oxide, or silica, which is best known as quartz and, in the granular condition, as sand. In the form of silicates it is also one of the most important constituents of the clays. Though of no known importance in the animal body, it occurs to some extent in both plants and animals.

CHAPTER IV

THE CONSTITUENTS OF FEEDS

FEEDING stuffs are not simple substances, but complex mixtures of intricate, though definite, chemical compounds, and as it is the utilization of these substances that is of importance in the feeding of animals, some knowledge of their nature is essential. In studying them from the feeding standpoint, however, it is not necessary to adhere strictly to a chemical discussion of the feed constituents; it is better to group them according to the functions which they perform in the animal body.

All of the substances found in feeding stuffs need not necessarily be of value to the animals consuming the feed, and those which have value are generally grouped together as nutrients. A nutrient may be stated to be any feed constituent, or group of feed constituents of the same general chemical composition, that may aid in the support of animal life. Used in the broadest sense, the term nutrient would include the oxygen of the air and drinking water, as they are essential to animal life, though their general abundance generally excludes them from discussion.

The feeding stuffs may be divided into water and dry matter, the dry matter being considered the more important as it is generally more expensive. The dry matter contains a very large number of materials, and may be divided into organic matter and inorganic matter, or ash. The latter is generally considered as a whole, while the other substances included in the term dry matter are grouped according to

their chemical nature, as carbohydrates, fats and proteins. The terminology used in feeding work is not always free from chemical inexactitudes, but it is sufficient when considering practical problems.

WATER

Water occurs in all feeding stuffs and is of much greater importance than is generally realized. The amount of it present varies very considerably, as only about 5 per cent of it is found in some grains and hays, while it may constitute as much as 90 per cent of some roots. Water is composed of eight parts by weight of oxygen and one part of hydrogen.

CARBOHYDRATES

The carbohydrates form a very large group of compounds of diverse properties. They obtain their name from the fact that they consist of carbon, hydrogen and oxygen, and the hydrogen and oxygen are present in the proportions in which they occur in water. This definition brings in a few substances, such as acetic acid, which are not carbohydrates. For feeding purposes the carbohydrates are divided into two main groups, the crude fiber, and the nitrogen-free extract. This is rather a vague grouping, but is quite suitable for practical purposes.

Crude Fiber.—When a feed is boiled with dilute acid and then with dilute alkali, all the more readily soluble substances are removed and the residue is known as crude fiber. This portion of the carbohydrate group is not a simple substance; it consists of the woody, more insoluble portions, such as the cellulose and the lignin of the cell walls of the plant.

Nitrogen-free Extract.—The nitrogen-free extract consists of a group of carbohydrates of similar nature and value. It is a very poorly defined group, as is shown by the method in which

it is determined in the chemical examination of a feed. When all of the other main groups of nutrients have been determined, the undetermined portion is grouped as the nitrogen-free extract. Typical examples of this group of nutrients are sugar, starch and similar compounds.

FATS

The fats, like the carbohydrates, contain carbon, hydrogen and oxygen, but the hydrogen and oxygen are not in the same proportions as in water. The true fats are compounds of glycerol and the fatty acids; but as the method used in determining them in the analysis of feeds is quite crude, other substances are generally included with them. To determine the amount of fat in a feed the material is extracted with ether, and as the resulting extract generally contains waxes, coloring materials and other substances in addition to the true fats, it is classed as ether extract, or crude fat. The amounts of fat present in the different feeding stuffs vary widely, and typical examples of them are corn oil and linseed oil.

PROTEINS

More complex in composition than either the carbohydrates or the fats are the proteins. In addition to carbon, hydrogen and oxygen, they always contain nitrogen and sometimes sulphur, phosphorus and iron. Chemically they may be looked on generally as compounds containing amino-acids. In feed analysis the method of arriving at the amount of protein present is to determine the percentage of nitrogen and multiply this by 6.25, as the amount of nitrogen in the various proteins in feeds is fairly constant. This method is not quite correct, however, as it also takes into consideration the nitrogen present in some non-protein substances which will be considered later. Where the protein is determined in this

way it is called crude protein, to distinguish it from the actual or true protein present.

So far, twenty-two amino-acids have been determined in the proteins of feeding stuffs, and even these vary greatly in complexity. In addition to the amino-acids, other chemical groupings also occur in some of the more complex proteins. The value of proteins for feeding purposes depends on the specific amino-acids which they contain, a problem which will be discussed under the utilization of the nutrients. The proteins are the characteristic constituents of the animal body in contradistinction to the carbohydrates, which predominate in plants. Some typical proteins are the albumin of egg-white, the caseinogen of milk and the gluten of wheat.

NON-PROTEIN NITROGENOUS COMPOUNDS

This is a poorly defined group of substances of doubtful feeding value. As already mentioned, they are generally included with the true protein under the term crude protein in the analysis of feeding stuffs, as their determination requires a considerable amount of chemical work. They do not generally occur in large amounts in feeds and are most frequently found in young, immature plants. One of the best-known substances in this group is asparagin, which occurs in asparagus and many other plants.

VITAMINES

The vitamines, or food accessories, have been only recently recognized as of importance in animal nutrition. Their functions are quite dissimilar to those of the other groups of substances mentioned here. Three so-called vitamines are now recognized, Fat-soluble A, Water-soluble B and Water-soluble C. Their names are derived from the substances in which they are dissolved, but so far their true chemical

nature has not been determined, as they are present in feeds in extremely small proportions. Their distribution is not uniform throughout the feeding stuffs, but this can best be discussed in connection with their functions.

PIGMENTS

Pernaps the most characteristic coloring material of plants is the green pigment, chlorophyll; but of more importance, so far as the feeding of dairy cattle is concerned, is the group of yellow pigments known as the carotinoids. These are found associated with the green pigment and also alone, as in the case of carrots. The chief members of this series are carotin, which was first isolated from carrots and the xanthophylls. The pigments occur in plants in but small amounts and are of no known nutritive value, their importance being due to the influence they have on the color of milk.

ASH

Excluding the vitamines and pigments, the ash is generally the smallest constituent of the common feeding stuffs, though by no means the least important. The ash contains a large number of inorganic compounds, and as it is determined by burning the feed and weighing the residue it also includes not only these inorganic compounds, but also constituents, such as 'ron and phosphorus which occur in organic combination in the feed.

There is practically no limit to the variety of elements occurring in the ash, but among the more common are calcium, magnesium, sodium, potassium, phosphorus, sulphur, iron, chlorine and silicon.

CHAPTER V

DIGESTION AND ABSORPTION

When an animal consumes feed, the material ingested is generally of no immediate value to it. The feed materials must be converted into forms which can be assimilated by the animal body; this is the function of digestion, which is followed closely by absorption, or the transference of the digested nutrients from the alimentary tract into the tissues of the animal. The processes of digestion and absorption are complicated ones and all is not yet known about them. A certain knowledge of these activities is necessary, however, for a proper understanding of the principles of feeding.

The digestive processes of the farm animals, as well as those of man, are all based on the same broad general principles, though there are some wide modifications due to differences in the structure of the digestive tract and the character of the feed adapted to the use of the various types of animals. There is thus a closer relationship between the digestive processes in man and the pig than there is in those of the horse and the cow. Only those of the cow will be discussed here.

In discussing digestion the best method appears to be to start with the feed as it is taken in at the mouth and carry it through the digestive system, noting the changes and actions which occur in each section. This method renders impossible the complete discussion of the digestion of any one nutrient at a time, but it permits all the functions of one organ to be discussed collectively.

THE MOUTH

The first function of the mouth is the prehension of the feed, and in this process the long, rough-surfaced tongue plays an important part. The incisor teeth and the pad on the upper jaw are also used in biting off grass, though they are not so useful for this purpose in the case of the cow as they are in the case of the sheep. This is due to the absence of the split upper lip and explains why cattle do not cut pasture so close as do sheep.

After the feed enters the mouth it is masticated rapidly and rather incompletely and swallowed. Later this feed is regurgitated, a process to be discussed further, and is then masticated slowly and thoroughly. This is known as cudding, or chewing the cud. In the process of mastication the jaws move not only upward and downward but also laterally, and feed is masticated only in one side of the mouth at a time.

During the process of mastication the salivary glands perform an important function. There are three pairs of these glands, known as the parotid, sublingual and submaxillary, and the ducts from one of each of the pairs pour out saliva in the right half of the mouth and the others in the left. The salivary glands are most active during mastication, but they also secrete to some extent even when mastication has stopped.

Saliva consists mainly of water, but it contains a number of substances in solution, including two enzymes known as ptyalin and maltase. The first function of the saliva is to moisten the feed, both before it is swallowed and after it has been regurgitated for further mastication.

The amount of saliva secreted depends largely on the nature of the feed; with dry feeds, such as hay and oats, large amounts of it are secreted while with silage or roots the secretion is reduced. Where dry feed only is provided, the

cow may secrete 10 to 12 gallons or more of saliva daily. The mastication, or grinding of the feed into fine particles, and the moistening of it with saliva are merely mechanical preparations to bring the feed into proper condition for true digestive action.

The remaining function of the saliva is due to the presence of its two enzymes, ptyalin and maltase, and their actions are important. Enzymes are substances of unique powers. Their composition or constitution is not understood, but they have the property of bringing about chemical changes without themselves forming any part of the resulting products. In fact, under suitable conditions, where the end products are removed, a very small quantity of enzyme can keep some chemical change going on continually and not be itself affected.

The ptyalin of the saliva acts on the starch of the feed, which takes up water and is converted into maltose and dextrin. The maltase, which is of less importance, acts on the maltose and converts it into dextrose. It is essential for the operation of these enzymes that the medium in which they work contain no free acid, and so the saliva is normally alkaline in reaction.

THE STOMACH

In the horse and man, and, in fact, in all other mammals except the ruminants, there is but a simple stomach, whereas in the cow and other ruminants there are three other compartments besides the true stomach. Sometimes these are all called stomachs, and the cow is then said to have a stomach with four compartments, or even four stomachs; but as a matter of fact she possesses a true stomach and three compartments which are really enlargements of the œsophagus or gullet. In the order of their occurrence in the digestive tract, they are the rumen, reticulum, omasum and abomasum.

Considering these four divisions as a whole, it may be said that they fill about three-fourths of the abdomen of the ruminant, the greater portion of them being in the left half of the body cavity.

The total capacity of these compartments varies from 30 to 60 gallons, depending largely on the size and age of the animal. It must also be remembered that these compartments do not arrive at their final relative sizes until the animal is about one and a half years of age. Then the rumen constitutes about 80 per cent, the reticulum 5 per cent, the omasum 7 to 8 per cent and the abomasum 8 to 7 per cent of the total capacity. In the new-born calf conditions are very different; the rumen and reticulum combined are about half as large as the abomasum, and the omasum is small and apparently functionless. By the time the animal is about three months old the combined volume of the rumen and reticulum is about double that of the abomasum, and in another month they are about four times as large as the omasum and abomasum combined. From then on, the development continues until the various compartments reach their ultimate relative sizes.

Rumen.—The rumen, or paunch, is not a simple cavity but is somewhat divided into sacs by muscular pillars, and the mucous membrane lining it is studded with small projections or papillæ. Beginning at the point of entrance of the œsophagus into the rumen is the œsophageal groove. This is a canal with an incomplete wall. It passes along the edge of the rumen and ends at the opening to the reticulum and omasum.

While the animal is feeding, most of the feed passes into the rumen. The rough, coarse feed and practically all the water goes there, though some water may go to the reticulum through the œsophageal groove, and any excess may pass on to the omasum and abomasum. Some of the finer material

of the feed may also pass on through the œsophageal canal without really entering the rumen.

The feed and water gathered in the rumen do not remain there inactive, as the mass is kept rotating, this action being most marked during rumination and just after drinking. The contents are thus thoroughly mixed.

No true digestive fluids are secreted in the rumen, although some mucous material is liberated. Nevertheless, chemical action is continually going on. The enzymes brought to the rumen by the alkaline saliva continue to function. The contents of the rumen vary in reaction, however, some being alkaline on account of the saliva while other portions are rendered acid by fermentative processes going on in parts of the feed. Of the cellulose in the feed, about 15 per cent is digested by bacteria and by enzymes contained in the feed itself. Although these changes in the carbohydrates of the feed are taking place, the main function of the rumen is to store and macerate the feed and in this way prepare it for further digestion.

When a cow starts to ruminate, the rumen becomes quite active and its contents are kept moving toward the œsophageal groove for the purpose of regurgitation. Then portions of the feed, about 4 ounces in weight, are separated from the main mass and returned to the mouth for mastication.

Reticulum.—The œsophageal groove affords a means of communication between the œsophagus and the reticulum, or honeycomb, while communication between the rumen and reticulum over the wall separating them is easy, and there is also an orifice which serves as a means of communication between the reticulum and omasum.

The mucous membrane lining the reticulum has the appearance of a honeycomb and secretes no digestive fluids. The contents are watery in nature and alkaline in reaction. As a rule feed does not pass into the reticulum and its main

function seems to be in aiding rumination. The walls can be contracted and the alkaline fluid passed over into the rumen where it helps in the preparation of the feed for further digestion. One of the peculiarities of the reticulum is that it is here that the nails, old wire and other "objets d'art" swallowed by the cow are generally collected.

Omasum.—The openings of the omasum, or manyplies, which communicate with the reticulum and abomasum are both on its lower side, and a groove in its lower wall forms a direct passage, for fluids and fine materials which need no further preparation, from the reticulum to the abomasum. The omasum is lined with leaves of various sizes and covered with horny papillæ, the function of which is to macerate feed which has not been finely ground. It secretes no digestive fluid and takes no part in absorption, while its contents are neutral in reaction and normally dry.

After rumination, the material swallowed passes through the œsophageal groove and to the omasum. Much of the liquid and finely ground material passes on through the groove in the lower surface of the omasum to the abomasum, but the other material is macerated by the leaves of the omasum and then passed on. It is probable that the changes started by the enzymes of the saliva, and by bacteria in the rumen and the enzymes of the feeds themselves, continue up to this time.

Abomasum.—The abomasum, or true stomach, is the only one of the four so-called stomachs of the cow in which true digestion takes place. The abomasum is lined with mucous membrane, in certain portions of which are located glands which secrete the various constituents of the gastric juice. The various sets of glands have different functions to perform, but the main constituents of the gastric juice are hydrochloric acid and the enzymes, pepsin, rennin and gastric lipase.

The feed entering the abomasum is in a finely divided form and alkaline in reaction, and as it is gradually mixed with the

gastric juice the hydrochloric acid renders it acid in reaction; but as the hydrochloric acid has, first of all, to unite with the alkali, it is some time before the action of the enzymes of the saliva ceases breaking down the starches and maltose. When the medium becomes acid the pepsin acts on the proteins, breaking them down into the simpler bodies, peptones and proteoses. This action is continued in the intestine.

In older animals, the enzyme rennin appears to have little to do, but in the case of calves its function is important. Like pepsin, it acts only in an acid medium, and when the milk in the stomach of the calf has been rendered acid the rennin coagulates the protein, caseinogen, thus preparing it for the action of the pepsin.

The gastric juice sets free the fats of the feed, mainly by the solution of the materials surrounding them, though when the fats are in a finely divided form, as in milk, the enzyme lipase may act on them, breaking them down into free fatty acids and glycerin. When the contents of the abomasum have become mixed with the gastric juice and a certain degree of acidity has been reached, the pylorus, which separates the abomasum from the small intestine, opens. Part of the contents then pass to the intestine.

THE INTESTINE

The intestine is not a simple canal but is divided into several more or less distinct sections. It is divided, in the first place, into the small intestine and the large intestine. The small intestine consists of the duodenum, jejunum and ileum, while the large intestine, which is wider but shorter than the small intestine, is made up of the cæcum, the colon and the rectum.

Small Intestine.—When the acid contents of the stomach enter the small intestine they meet an alkaline medium in the duodenum. The partial neutralization of this by the acid from the stomach leads to the closing of the pylorus, which

does not open again to allow of further feed passage until the material in the duodenum has been rendered alkaline.

The walls of the small intestine are lined with a mucous membrane which secretes a digestive juice; the bile and the secretion from the pancreas also enter the duodenum. These secretions are all mixed with the material from the stomach and have an important part to play in intestinal digestion.

When the partially digested feed, or chyme, passes from the stomach to the intestine, the hydrochloric acid which it contains acts upon a substance called prosecretin, which is present in the mucous membrane of the duodenum and converts it into secretin. The secretin in turn is carried by the blood to the pancreas and stimulates the production of the pancreatic juice. The pancreatic juice is poured into the duodenum through two ducts and, being alkaline in reaction, neutralizes the acidity of the chyme. In addition it contains three enzymes or the substances from which they are derived. These are trypsinogen, which is inactive in that form, amylase and steapsin. On entering the duodenum, the trypsinogen comes in contact with enterokinase which is formed in the mucous membrane of the intestine. The enterokinase converts the inactive trypsinogen into active trypsin, which acts on the proteins of the intestinal content and breaks them down further than was done by the pepsin of the stomach. The trypsin really completes the work started by the pepsin, and the end products of protein digestion are in the main amino-acids.

The amylase of the pancreatic juice converts the starches into the sugar maltose and the steapsin splits the fats into fatty acids and glycerin.

The bile is continually formed by the liver, and is stored in the gall bladder and forced into the duodenum when chyme enters thereinto from the stomach. The bile carries off a large amount of waste material, but plays some part in di-

gestion, though this function is not well understood. It aids in the breaking down of the fats into fatty acids and glycerin, but the manner in which it acts is not known, though it greatly assists the steapsin or lipase of the pancreatic juice.

The secretion of the gland cells of the small intestine is known as the succus entericus. Part of the functions of the small intestine, in the production of secretin and enterokinase, have already been mentioned; but in addition it produces a number of enzymes. One of these is erepsin, which converts the proteoses and peptones which have been formed in earlier protein digestion into amino-acids, while another is nuclease, which breaks up the complex nucleic acids into simpler compounds. In addition it contains a number of inverting enzymes maltase, invertase and lactase, which act on the disaccharides, such as maltose, sucrose and lactose, and convert them into simple sugars like glucose, fructose and galactose.

These various enzymes, acting in the small intestine, complete the changes started by those of the mouth and abomasum and finally prepare the material for absorption into the body of the animal. It is true also that stomach digestion is continued for a short time in the small intestine, until the chyme has been rendered alkaline.

Absorption is the process by which the nutrients, which have been digested in the alimentary canal, are absorbed and taken into the circulation of the animal. It is probable that very little, if any, absorption takes place before the feed reaches the small intestine, but there it becomes very active.

The surface of the small intestine is studded with millions of small processes known as villi, and it is through these that actual absorption takes place. The villi are copiously provided with capillaries from the arterial and venous blood systems and from the lymph system. The lymphatics take up the products of fat digestion, while the capillaries of the

venous blood system absorb the end products of the digestion of proteins and carbohydrates, and in addition take up a large amount of water and ash materials.

Large Intestine.—When the material from the small intestine passes through the ileocæcal valve to the large intestine the activities of the enzymes acting in the small intestine continue and the process of absorption is completed there. The large intestine is lined with a smooth mucous membrane, free from villi; but it is provided amply with capillaries from the blood and lymph systems, and these perform the same functions as they did in the absorption process in the small intestine. Even in the rectum, the last division of the large intestine, this process continues.

The processes of digestion and absorption are not absolutely efficient, and so not all of the materials in the feed are digested and not all of the digested materials are absorbed. The efficiency of the processes, of course, depends to a considerable extent on the nature of the feed. This means that a considerable amount of refuse is left, and to this are added waste materials cast off in the bile and by other routes. The material left in this way is passed from the body as the fæces.

CHAPTER VI

THE UTILIZATION OF NUTRIENTS

THE utilization of the nutrients in the animal body involves a large number of processes which are generally considered under the subject of nutrition. Without taking up all of the nutritive processes, however, some knowledge can be obtained of the uses to which the nutrients are put in the animal body and the ultimate benefits which the animal derives from them.

THE BODY ACTIVITIES

The various processes which go on in the animal body are innumerable and complex, and though some of them are fairly well understood, many of them must still be discussed theoretically or, at best, with but a mere approximation of the truth. Broadly, however, the body activities can be divided into two main groups—those connected with the maintenance of the body and those concerned with production. The term production includes such activities as growth, fattening, fetal development, milk production and work. All of these, with the exception of work, are of importance to the feeder of dairy cattle and must be given consideration.

Maintenance.—When the live weight of an animal that is not working is kept uniform for a period of time, it is generally considered as being on a maintenance ration. Practically, this is nearly correct, but technically it is not, as an animal may remain constant in live weight and yet not have uniform amounts of nutrients and energy stored in its body. This is due to the fact that the tissues may lose some dry matter and

receive an extra supply of water, and that at times protein may be replaced with fat, or vice versa, and so alter the amount of energy stored in the body.

Whatever may be the conception of maintenance, nutrients are necessary to maintain the animal, and as maintetenance of the animal and all its vital body functions is essential, the nutrients necessary for it must be supplied in the ration. Other nutrients must be provided over and above the maintenance requirements for the productive body activities. It is the production of something by the animal from the feed supplied that brings the returns to the farmer; mere maintenance is not sufficient.

Fattening.—The fattening of animals is one form of production that is easily recognized. It consists simply of the production and deposition of fat in the body from the nutrients supplied in the feed. It is of more importance with beef than with dairy cattle; but even with the latter it must not be overlooked, as the cow will not do her best work when in poor condition, and she should be in good condition before freshening, to ensure the supply of body nutrients which can be used in the next lactation for the production of milk and butter fat.

One of the primal instincts of the animal is preservation. As a consequence of this and of the fact that less work has to be expended in using the nutrients for body maintenance than in using them for the production of body fat the animal uses the feed needed for maintenance more efficiently and with less waste than it does that used for fattening. However, there is little difference in the efficiency with which the feed is utilized for those two groups of body activities.

Growth.—The importance of growth is evident, and the provision of feed for this purpose must be made in the case of all young, immature animals. Too many of the failures of cows to produce profitably are due to the fact that they

have received poor feed in insufficient amounts while still undergoing development. The efficiency with which feed is used for growth is somewhat less than in the case of fattening, probably due to the fact that more energy is used up in the conversion of nutrients into new tissue substance, in growth, than in the conversion of an equal amount of nutrients into body fat.

Fetal Development.—In the case of the dairy cow, the regular production of a calf is essential to true economy, and nutrients must be provided for the development of the fetus. From the limited amount of work available it appears that the nutrients are used less efficiently for the development of the fetus than for any of the general body activities first mentioned. This is undoubtedly due to the fact that the formation of a new individual requires the expenditure of even relatively more energy than is needed in the growth activities.

Milk Production.—The nutrients supplied to a cow for the production of milk and butter fat are used more efficiently than those supplied for any other productive purpose or even for maintenance. This is perhaps due to the fact that it is easier to convert feed fat into milk fat, feed protein into milk protein, and so on, than it is to convert all feed nutrients into body fat or body protein, even to use them simply for maintenance. This is in spite of the fact that the nutrients are to some extent used interchangeably for the formation of milk sugar and butter fat. It is simply a demonstration of one of the great fundamental functions of all living organisms—preservation of the race: the cow can use her feed more efficiently for the production of milk, presumably to feed her calf, than she can use it for her own maintenance. It is this fact, more than any other, which makes the cow the most efficient of farm animals, so far as the conversion of farm products into human food is concerned.

COMPARISON OF THE NUTRIENTS

The nutrients are used for a variety of purposes and in some cases they can be used interchangeably. As a consequence some methods of comparison are essential to a proper understanding of their interrelationships.

Digestibility.—Not all the nutrients consumed by an animal are utilized in its vital processes. As the feed passes through the alimentary tract it is acted on by the digestive juices and a part of its nutrients absorbed there. This portion absorbed in the digestive tract is known as the digestible portion and includes the digestible protein, digestible fat and digestible carbohydrates. These must be taken into consideration in studying the value of a ration to animals. The average percentage of a nutrient digested from a feed is called the coefficient of digestibility, or digestion coefficient, for that nutrient in the feed. The feed not digested passes out in the fæces.

Digestible Carbohydrate Equivalent.—It has already been noted that the carbohydrates and fats are the chief sources of energy for the animal body, and it has been found convenient to use the term carbohydrate equivalent for these two energy-supplying nutrients taken together, so that they may be compared on a common basis. The digestible carbohydrate equivalent of a feed is its percentage of digestible carbohydrates plus 2.25 times its percentage of digestible fat, as one pound of fat will provide 2.25 times as much energy as will a pound of carbohydrates.

Total Digestible Nutrients.—The term total digestible nutrients signifies the sum of the digestible crude protein and the digestible carbohydrate equivalent. Owing to the fact that fat is more valuable for energy-producing purposes than are carbohydrates, this sum is a better indication of the

value of a feed than would be the sum of the digestible crude protein, digestible carbohydrates and digestible fat.

Nutritive Ratio.—A knowledge of the relation of the protein to the non-protein constituents of a feed is frequently desired. This relation is expressed by the nutritive ratio, which is the ratio of the digestible crude protein to the digestible carbohydrate equivalent of a feed.

Energy Values.—It has been found that a knowledge of the digestible nutrients of a ration does not always give a true indication of the ultimate value of the ration to an animal. This is due to the fact that the animal body is a transformer of energy, and equal weights of digestible nutrients do not necessarily provide equivalent amounts of energy. Consequently some other measure of value for feeds is often needed in addition to those already mentioned.

Energy may be defined as the capacity for doing work, and as heat is a form of energy which is easily measured, and as other forms of energy can be expressed in terms of heat energy, the heat which a feed can provide is taken as a measure of its energy value. The unit of measurement for heat energy used in nutrition work is the therm, which is the amount of heat required to raise the temperature of one thousand kilograms of water one degree Centigrade or of one thousand pounds of water nearly four degrees Fahrenheit.

The amount of heat obtained by completely oxidizing a feed, or burning it in a good supply of oxygen, is its gross energy. This represents what the animal could obtain from the feed in the way of heat or other forms of energy if the processes of nutrition were absolutely efficient.

However, there are many losses which must be taken into consideration. The first series of these occur before the nutrients have had the opportunity of entering into the metabolic processes of the animal. The energy lost in this way is carried away by the excreta. The fæces contain a

large amount of undigested material and, in addition, excretory products, such as some of the constituents of the bile, which contain materials that are incompletely oxidized. The intestinal gases consist of methane and other materials which could be further oxidized. In the urine also urea and other materials pass off, which if completely oxidized would provide some energy, while the secretions of the sweat and sebaceous glands of the skin and the cast-off hair also contain substances carrying off energy from the animal body. When the energy contained in all these materials is deducted from the gross energy of the feed the metabolizable energy is left. It may be defined briefly as the gross energy of the feed less the gross energy of the excreta; it constitutes the maximum amount of energy which the feed can actually contribute to the energy in the animal body.

However, there are some losses from the metabolizable energy. The mechanical work involved in the prehension and mastication of the feed and in its transportation through the digestive tract involve an expenditure of energy. An additional amount of energy is also used by the salivary and other glands of the digestive tract in the preparation of their secretions for action on the feed. It is possible that digestion and absorption and the changes taking place in the nutrients after absorption may also involve an expenditure of energy, though this is not certain. It is known, however, that the actual presence of the nutrients in the cells of the body does lead to greater heat production.

All of this second series of losses of energy are directly due to the consumption of the feed; and the metabolizable energy, less the energy expended in these processes, is termed the net energy value of the feed. The term net energy expresses the gain of energy to the animal body that results from the consumption of the feed.

FUNCTIONS OF THE NUTRIENTS

The various classes of nutrients have definite functions to perform in the animal body, though in some cases the duties of one nutrient can be taken over to a certain extent by nutrients of another class. Only a few of the general functions can be considered, however, as many of the interrelationships of the nutrients are not yet understood.

Water.—Water is absolutely essential to animal life. It probably has more functions to perform in the animal body than any other nutrient. First of all, the water supplied to a cow, either in the feed or as drinking water, plays an important part in the digestion and absorption of other nutrients. It is also required for the preservation of the turgidity of the tissue cells and as a means of rendering possible, through solution, the transportation of the other nutrients from one part of the body to another and to the fetus and mammary glands. Its importance in the production of milk is easily seen when it is known that 87 per cent of milk is water.

In addition to these functions, water enters into chemical combination with other nutrients and is thus used in the actual building up of tissue. It aids in the proper elimination of undigested materials in the fæces and is absolutely essential for the carrying away of waste products in the urine. It is also a regulator of body temperature.

Carbohydrates.—The two groups of carbohydrates, crude fiber and nitrogen-free extract, fulfill very similar functions in the animal body, but they should be considered apart. The crude fiber performs a very important function in the alimentary tract. For ruminants, a bulky ration is necessary to stimulate proper digestion, and the crude fiber of the ration has much to do in rendering the ration bulky, though

other constituents also play their part. In other ways the functions of the crude fiber are the same as those of the nitrogen-free extract.

The main function of the nitrogen-free extract is to provide heat and energy to the animal body. The nitrogen-free extract, with the crude fiber, forms the main source of these. It may also be converted into fat and stored in the animal body as such, or it may be used in the production of milk fat and sugar.

Fats.—The fats are more concentrated heat producers than any other of the groups of nutrients. They help in the production of the fat and sugar in milk and are also used as material to be stored up in the body. Each pound of fat is capable of producing 2.25 times as much heat or energy as a pound of protein or carbohydrate.

Proteins.—The proteins are used for building up new tissue and replacing tissues that are worn out. They are absolutely essential to the welfare of the animal. When more protein than is necessary for tissue building is supplied, it can be used for the production of heat and energy, or part of it may be converted into body fat.

In pregnant animals proteins are required for the growth of the fetus and its enveloping membranes. After parturition a considerable amount of protein is used in the production of the milk proteins and may also be used, if present in the feed in sufficient quantity, for the formation of milk sugar and fat.

Non-protein Nitrogenous Compounds.—The statements just made apply to the crude protein, though the non-protein nitrogenous constituents are not as valuable to the animal body as are the true proteins. However, when true proteins are lacking in the feed, and a sufficiency of non-nitrogenous organic constituents is present, they can take the place of true protein to a certain extent in animal metabolism.

Vitamines.—For the dairy cow, the absolute necessity of the vitamines, or food accessories, has perhaps never been definitely proved. The amounts stored in the body, though of vegetable origin, are large enough to carry the animal through very long periods, and when she goes to pasture she probably has their stores replenished.

The vitamines, of which three are now recognized, are necessary for normal maintenance, growth and reproduction, and are even absolutely essential for life itself. In the case of the cow a supply of vitamines in the feed is especially necessary, in order that the normal amount of them may occur in the milk. Work at the Iowa Agricultural Experiment Station perhaps indicates the necessity of vitamines for calves, and elsewhere results are being obtained which indicate that the cow will tend to produce a vitamine-free milk if sufficient vitamines are not provided in the ration.

Most of the information available has been obtained through experimental work with laboratory animals, and studies of the dietaries of humans where certain deficiency diseases occur. Unfortunately, little is known of the actual nature of the vitamines. It is known, however, that their absence from the diet leads to deficiency diseases which are frequently accompanied or followed by other diseases which take hold on account of the general weakness of the subject. The vitamines are believed to be nuclear nourishers, and many cases of indisposition may be due to too low a supply of vitamines.

The vitamines are all of vegetable origin and are essential for all the higher animals. While they do occur in certain animal tissues and products, even in those cases they are originally derived from vegetable products. The herbivorous animals get their supply direct from the plants, while the carnivorous animals derive their supply from certain organs of their victims. The formation of vitamines in the animal

body has not been demonstrated. An adequacy of vitamines is needed for both old and young, though this necessity is generally most evident in the case of the latter.

The lack of Fat-soluble A leads to the eye disease known as xerophthalmia, and rickets are also attributed to it. Absence of Fat-soluble A for a sufficient length of time results in death.

The most important source of this vitamine is butter fat and the quantity of it present ultimately depends on the feed of the cow. The chief vegetable sources of Fat-soluble A, from which the cow derives her supply, are the leafy forages, such as grass, clover, alfalfa and cabbage. Yellow corn may contain enough of it, but white corn is valueless as a source of Fat-soluble A. Colored roots, as carrots and sweet potatoes, contain it, but sugar beets, mangels and potatoes have little or none.

It should be noted that all of the sources of Fat-soluble A mentioned have yellow coloring matter, though in some cases it is associated with the green pigment, chlorophyll. It may be that Fat-soluble A is a yellow plant pigment or a closely related compound.

The absence of Water-soluble B from the ration leads to polyneuritis or beriberi in man and animals, and for this reason this vitamine is frequently called the anti-neuritic vitamine. Its absence from the ration will ultimately lead to the death of animals. One of the noticeable changes due to prolonged lack of Water-soluble B is atrophy of the testicles and ovaries. The decrease in size may exceed 90 per cent in the case of the testicles and 60 per cent in the case of the ovaries. This results in sterility.

Water-soluble B is not so abundant in milk as is Fat-soluble A, but it occurs in the seeds of cereals and in a number of leguminous seeds, such as beans, peas and soybeans, cabbage, potatoes, carrots, turnips and beet roots. It is found most abundantly in the germ of the cereal grains, and ordinary

bran contains little. It is found in the green forages such as the grasses and legumes, but the hays contain little of it.

The vitamine known as Water-soluble C is anti-scorbutic, that is, it prevents the onset of, and cures, scurvy. Its absence from the ration ultimately results in death. It is needed by both young and old.

The anti-scorbutic vitamine occurs in small amounts in milk, and it is found in green plants and in such feeds as cabbages, beet roots, and carrots, though it has not been detected in the seeds of cereals or legumes.

The vitamines are essential for all animals, but where the cow is provided with a ration containing plenty of variety and some succulence she will seldom lack them in her ration.

Pigments.—Until recent years little was known regarding the coloring materials present in milk, but it has now been shown at the Missouri Agricultural Experiment Station that the pigments of milk are interesting in character. One group of pigments, the carotinoids, consist of carotin and xanthophylls, and as they are associated with the butter fat they are called the lipochrome, while another pigment found in solution in the milk serum is called lactochrome.

Carotin and the xanthophylls are closely related substances which are found widely scattered in plants and are always present in the chlorophyll-bearing parts. It has been shown that those coloring materials, when present in milk and in the bodies of animals, are identical with the plant pigments. The two classes of pigments mentioned above are intimately connected with the fat globules present—probably as adsorption compounds. They are not made in the body of the animal but are derived directly from the feed pigments. It has been shown that feeds rich in these pigments will color the butter fat highly and that the withdrawal of these substances from the feed will after a time result in a loss of color by the butter fat. The delay in this loss of color is due to the

fact that some pigment is stored up in the body when excess of it is fed and this can later be drawn on for the coloring of the butter fat. The rich color of milk in summer is due to the large amounts of carotin and xanthophylls in the green feeds consumed, while the white butter found in winter time is usually due to a lack of these constituents in the feed.

There is some variation among the breeds of dairy cattle in respect to the maximum color of the milk fat under conditions equally favorable for the production of a high color. The Guernsey breed produces milk notably rich in these pigments, while the butter from Holstein milk is relatively poorly pigmented. Many people believe that the degree of pigmentation of milk varies directly with the percentage of fat present and so are willing to pay a higher price for yellow milk than they otherwise would; consequently, milk pigments have a tangible commercial value in some sections.

Normally all cows produce a highly colored milk fat for a short time after parturition. Probably much of this pigment comes from the supply stored in the body, chiefly in the fat, and it is made available for the milk by the physiological conditions attending the secretion of milk about the time of freshening.

As already stated, the yellow pigments in the fat and other parts of the body are the same as those found associated with the milk fat. Similarly, the yellow secretions of the skin so characteristic of the Guernsey, but also found in less profusion in the case of other breeds, contain xanthophyll and carotin. There is a correlation between the color of this secretion and the color of the milk, but the presence of an abundant yellow skin secretion does not indicate that an animal will produce highly colored milk under all conditions; the pigments must be supplied in the feed before they will appear in the milk. Evidently some breeds, and individuals

within the breeds, are more susceptible to pigments than are others.

The lipochrome, or fat pigment, in milk is composed largely of carotin, the xanthophylls being present in small quantities only. This is due to the fact that carotin is assimilated from the feed of the cow in preference to the xanthophylls, perhaps partly because of its greater stability toward the juices of the digestive tract. The carotin, as carried by the blood to the udder, is in firm combination with an albumin. The lactalbumin of cow's milk may be related to the color of the milk fat, and there appears to be a special relation between the high color and the high albumin content of colostrum. The carotinoids in the milk are derived directly by way of the digestive system and the blood stream from the carotinoids of the feed. It has been shown that there are individual and breed variations in ability to use those pigments, and generic variations also occur. The color in the fat of cows' milk consists mainly of carotin, while in the case of sheep and goats the xanthophylls predominate, even when the feed is very similar to that given to cows.

Lactochrome, the third pigment, is the one that colors whey. It is closely related to, if not identical with, the yellow pigment of normal urine—namely, urochrome. The breed of the cow is the most important factor in determining the amount of lactochrome in milk. It is the amount of lactochrome present that causes skimmed Jersey milk to appear richer than skimmed Holstein milk or sometimes even richer than whole Holstein milk.

Ash.—The ash, though usually the smallest constituent of a feed, is very important. It helps to build up and keep in repair the skeleton of the animal, and also the skeleton of the fetus of the pregnant female. In addition it takes part in many other important functions which, though less evident, are vital. Its presence in all living cells is essential and it

aids in the functioning of the nerves, the maintaining of the muscles in proper working condition, and the circulation of the blood. It is also responsible for the ash constituents of milk.

CHAPTER VII

THE INFLUENCE OF NUTRITION ON PRODUCTION

Because the ultimate source of milk, with all its constituents, is in the nutrients taken from the feed, it is interesting to note just what direct influence, if any, the nutrients of the ration have on milk production.

INDIVIDUAL NUTRIENTS

Each group of nutrients, such as the carbohydrates, fats and proteins, is made up of a large number of individual and distinct compounds. It is not possible to discuss these compounds in detail, but the main groups need attention.

Water.—The water consumed by the cow, either in the feed or as drinking water, is used in large quantities for milk production. There is no doubt that limiting the water supply of a milking herd will decrease the production of milk. Any factor which tends to decrease the total yield of milk also tends to increase the percentage of fat and other solids present, but the total yield of these will generally be decreased. Consequently if the amount of water in the ration is limited, the yield of both milk and butter fat will be decreased.

Carbohydrates.—The carbohydrates are used for the elaboration of both milk sugar and butter fat, but those materials can be made even in the absence of carbohydrates. The carbohydrates, as a group, have no direct influence on the yield or composition of the milk.

Fats.—The fats, perhaps more than any other class of nutrients, have been looked on as having a direct influence on the yield and composition of milk. However, this is in the man incorrect. The fats of the feed are used for the production of both fat and sugar in the milk, but normally they do not have any direct influence on the yield or composition of the milk. Sometimes, however, if the amount of fat or oil in the ration be increased markedly or suddenly there will be a temporary increase in the percentage of fat in the milk, and this may lead, depending on the change in the milk yield, to a comparatively small and temporary increase in the fat yield. On the whole, however, the fats in the feed have no influence on the yield or composition of milk.

Though this is true, the fats or oils of the ration may affect the butter fat in another way. Certain feeds, such as linseed-oil meal, peanut meal and the gluten products, which contain a fat or oil of low melting point, tend to produce a soft butter. as the fats from the feed or their fatty acids are used to some extent in the elaboration of the butter fat. In the same way, feeds, such as cottonseed meal, which contain fats of high melting point, tend to produce a hard butter.

Proteins.—The proteins are one of the most important groups of nutrients so far as milk production is concerned, as most of their functions cannot be fulfilled by nutrients of other groups.

Amount of Protein.—The protein of the feed is necessary for the production of milk protein and, when supplied in excess, can also be used for the production of the sugar and fat in the milk. It has been found that the supply of protein, if sufficient, has no influence on the composition of milk, and if proteins are deficient in amount they can be replaced to some extent, as already mentioned, by the non-protein nitrogenous compounds of the feed and by the use of body protein.

Much work has been done on the influence of protein on the total yield of milk and, although it has no influence on the composition of milk, it is very evident that a sufficient supply of protein must be provided if maximum production is to be obtained. It is not sufficient to provide just the amount of protein that the cow needs for maintenance, milk production and other purposes; some additional protein should be provided. This is due to the fact that the proteins are the only nutrients which actually stimulate milk production and a small excess of protein in the ration will generally lead to increased production. Too great an excess should not be provided, however, as this taxes the activity of certain groups of the body cells and ultimately results in lowered production.

Nature of Protein.—A fact that has only been recognized in recent years is that the nature, or quality, of the protein, as well as the amount of it, in the ration is of importance in connection with milk production. Proteins consist essentially of amino-acids with a few other constituents, and it is the nature of the amino-acids present which determines the value of a protein. Of the twenty-two amino-acids which occur in proteins, a few are of special importance. Of these, tryptophane is absolutely necessary for life and maintenance, and lysine for growth, while histidine, cystine and arginine, though not absolutely essential, aid growth. It can be seen therefore, that all of these five amino-acids are essential in the ration if best results are to be obtained.

The point of greatest importance in this connection is that all feeds do not contain all of the essential amino-acids. Feeds from a single-plant source are apt to be deficient in one or more of them. To avoid this deficiency, feeds from a number of plant sources should be given, as feeds from one source may frequently correct the protein deficiencies of those from another. Knowledge on this point is still in an ele-

mentary state, but it has been shown with milk cows that a good mixed ration is better for production purposes than one made up from one source only, such as the corn plant.

Non-protein Nitrogenous Compounds.—The non-protein nitrogenous compounds play but little part in the production of milk and have no influence on its yield or composition.

Vitamines.—As the vitamines in milk are derived from those in the feed of the cow, a vitamine-free ration would lead to a lack of vitamines in the milk and ultimately to a decreased production; the presence of vitamines is necessary to the well-being of the animal.

Pigments.—The pigments have no influence on the yield or composition of milk, though they do influence its color.

Ash.—As long as sufficient ash is present in the ration, the yield and composition of the milk is unaltered. If the ration is deficient in some ash constituent the cow will draw on the stores of ash in her own body to supply the necessary materials. When these body supplies run low the cow will still secrete milk of normal composition, but it will be decreased in amount. Eventually the cow will cease secreting to preserve the necessary minimum of ash constituents in her own body.

PLANE OF NUTRITION

The influence of the plane of nutrition on production can really only be studied by varying the plane of nutrition from normal and noting the changes that occur. The results given here regarding both high and low planes of nutrition are from work reported at the Missouri Agricultural Experiment Station.

Overfeeding.—It has been found that the chief effect of overfeeding is in the increased weight of the animal. There are no marked changes in the percentage composition of the milk or in the nature of the butter fat, though overfeeding has

a tendency to bring the composition of the milk and of the butter fat back to normal when some factor has been active in causing variations from the normal. Only in some cases does overfeeding tend to increase the total yield of milk, and even then the influence is quite limited.

On the whole, therefore, overfeeding has no specific influence on milk production, but it is a well-known fact that continuous overfeeding for a long period will result in the cow getting into very high condition, and that this will result in a decreased milk yield.

Underfeeding.—Underfeeding may be brought about intentionally, but there is another type of underfeeding which cannot be controlled. This is physiological underfeeding, and it very frequently occurs just after a cow freshens. At that time she is giving her maximum amount of milk and does not appear to be able to digest enough nutrients to meet the requirements of the mammary glands.

Underfeeding of either type results in a decrease in the weight of the animal. A reduction from a high to a low plane of nutrition leads to a high percentage of fat in the milk, especially if the cow is in good condition. The yield of milk is not decreased by physiological underfeeding or by underfeeding of any type just after parturition, but underfeeding later in the lactation period will result in a decrease in milk production. Subnormal nutrition, due to other than physiological causes, has a varying effect on the percentage of fat and other solids in milk. This should not be confused with the earlier statements made. The influence of underfeeding on the yield and composition of milk is consequently seen to be more marked than the influence of overfeeding.

In studying the influence of the nutrients on production it should be remembered that the cow tends, above all things, to keep the milk normal in composition, and when any nutrient, which cannot be replaced by another, is lacking in

the ration, the cow will draw on the stores of that nutrient in her body to make up the deficiency. When the body supplies run low enough to be near the danger point three courses are open to the cow: to decrease the milk yield, to alter the composition of the milk or to die. She almost invariably follows the first course.

PART III

THE REQUIREMENTS OF THE ANIMAL

CHAPTER VIII

FEEDING STANDARDS

For over a century attempts have been made at outlining feeding standards for farm animals. There have been repeated efforts to determine definitely a scheme which would show the amounts of nutrients required by the various types of animals for maintenance, growth, fattening, the development of the fetus and milk production. The different standards propounded have met with varying degrees of success.

DEVELOPMENT

About the beginning of the nineteenth century the interest of many workers began to center in the compilation of feeding standards for farm animals. The first standards were obtained from feeding trials in which one feed was substituted for another and the results compared. One of the feeds used was then taken as the unit of measurement and the values of the other feeds expressed in terms of a certain unit weight of the standard feed. Later it was found that owing to variations in the composition and digestibility of feeds this method was not absolutely reliable, and other types of standards had to be evolved.

Thaer, in 1809, was the first investigator to propose what can be called a feeding standard. His standard was based on the relative substitution values of feeds, the unit being a standard weight of good meadow hay. This work was the beginning of our present feeding standards and has been

very much modified. In Denmark and other Scandinavian countries there is in use at the present day a Feed-unit System, which is simply a slight modification of the Thaer Standard. This Scandinavian Feed-unit System is based largely on the work of Fjord. The feeding value of a definite weight of mixed grain is called one feed unit, and the values of all feeds are expressed in terms of this. In 1910 Hansson proposed a standard for dairy cows according to the Feed-unit System. He stated the requirements in terms of digestible protein and feed units.

Haubner, about 1840, and Lingenthal, in 1857, were the first really to attract attention to the fact that feeding standards should be based on the nutrients in feeds rather than on the gross weights of the feeds. In 1858 Grouven formulated a feeding standard based upon the crude protein, carboyhdrates and fats in feeds. He saw that owing to the wide variations in feeds something more definite than a Feed-unit System was desirable and he also made allowance for differences in the weights of animals.

Soon after this, Henneberg and Stohmann showed, as the result of digestion trials, that the amount of total nutrients in a feed does not form an accurate guide to its nutritive value and that digestible nutrients are a more accurate guide. In 1861, Kuhn first drew attention to the probable inadvisability of feeding all cows alike, irrespective of production or quality of feed; while in 1864, as the results of further work, Wolff proposed another standard based on digestible nutrients and made allowance for differences in the live weights of the animals. Later Kuhn proposed a standard which was more flexible than Wolff's and which distinguished between true protein and non-protein nitrogenous substances. In 1879, Lehmann modified the Wolff standard and made allowance for the amount of milk being produced by a cow.

Up to this time all the work on feeding standards had been

conducted in Europe, but from work done in 1894 and subsequent years, Haecker, of the Minnesota Experiment Station, proposed a standard which was based on the digestible crude protein, carbohydrates and fat, and which took into consideration not only the weight of the cow and the amount of milk being produced, but also the richness of the milk. Haecker has considerably modified his standard since he first proposed it, and it must be looked on as one of the great advances in the formulation of feeding standards.

Work by Kellner and Armsby has shown that there is a fallacy in using the digestible nutrients of feeds as a basis for feeding standards without paying attention to the source of the feeds. In 1907 Kellner published a standard which took into account the weight of the animal and the weight of milk produced. He made no definite allowances for milks of various qualities, but by allowing a variation in the amounts of nutrients required for each pound of milk he reached the same end. His standard is based on digestible true protein and starch equivalent.

Armsby, of the Pennslyvania Agricultural Experiment Station, by the use of the respiration calorimeter, was able to determine the net energy used by animals for various purposes and the amounts of it supplied by different feeds. With his results he formulated a feeding standard which was based on the requirements of the animal for digestible true protein and net energy. He allowed for the weight of the animal and the amount of milk, but not for the richness of the milk. In 1913, Eckles, of the Missouri Agricultural Experiment Station, taking Armsby's standard for maintenance as his basis, formulated a standard for production, based on the yield and quality of milk and expressed in terms of digestible true protein and net energy, while in 1916 Armsby proposed a standard for milk production which is a modification of the one just mentioned.

Savage, of Cornell, published in 1912 a study on feeding standards recommending a feeding standard which was a modification of the Haecker standard and was expressed in terms of digestible crude protein and total digestible nutrients.

From work done at the Wisconsin Station, Woll and Humphrey proposed a standard based on the total dry matter, digestible crude protein and total digestible nutrients; while Morrison, as a result of the work of Haecker and Savage, proposed in 1915 a modification of the Wolff-Lehmann Standard, expressed in terms of digestible crude protein and total digestible nutrients. Since then, Morrison has modified his standard after consideration of other work. He now allows for a range in the requirements for both digestible crude protein and total digestible nutrients. This is the standard given in Appendix II.

There are decided advantages in this standard. It allows variations in the amounts of nutrients supplied, so that the requirements of the individual cow can be more easily met. Again, it allows the changing of the relative amounts of protein supplied. This is very desirable, because in some localities, such as the South and the alfalfa regions, protein may at times be relatively cheap and so can be economically fed in greater proportions than would otherwise be the case.

CRITICISMS

For the purpose of discussing the relative values of the feeding standards and their general use, they can easily be divided into four groups, according to the nature of the terms in which they are expressed. Standards of the same type, though varying somewhat in their requirements, are all subject to the same general limitations.

Standards Based on Gross Weight.—The main objection to standards of this class is that feeds vary not only in the amounts of dry matter which they contain, but also in the

relative proportions of the various nutrients which constitute the dry matter. Owing to these variations and to the fact that the digestibility of the nutrients and the amounts of net energy which they provide also vary the different feeds cannot be accurately compared for nutritive purposes on the basis of their gross weights.

On the other hand, standards such as the Scandinavian Feed-unit System have some distinct advantages. They are very practical and easy to use. They are extremely useful as a guide to the economy of production of the animals within a herd or even of herds in a limited community. In this case the feeds used are all very similar in composition and so the error due to variations in the composition of different samples of a given feed are reduced to a minimum. In the cow-testing associations of Scandinavia this system is used widely and has given very satisfactory results.

Standards Based on Total Nutrients.—These standards are free from the first objection to the standards already discussed as they take into consideration the total nutrients in the feeds. However, the nutrients present vary in digestibility and as it is only the digestible nutrients that are of value in nutrition these standards also are quite inaccurate.

Standards Based on Digestible Nutrients.—Standards of this class are a considerable improvement over those of the two previous groups. They eliminate the main errors due to the variations in composition and digestibility of the feeds. The earlier standards of this type made no allowance for variations in the weight of the animal, the yield of milk or the composition of the milk. The Kuhn Standard was the first of these to be really flexible, while the Wolff-Lehmann Standard made some allowance for variation in the amount of milk produced, though Haecker and other modern investigators believe that the variations given were not as wide as they might be.

The Wolff-Lehmann Standard, which was the leading one for many years, made no allowance for variations in the composition of the milk; and to Haecker, of Minnesota, is due the credit of having proposed the first feeding standard that made allowance for this. The work of Haecker appeared to show that the Wolff-Lehmann Standard called for an excess of nutrients; but as Haecker fed considerable amounts of concentrates to his experimental animals this fact loses much of its significance, as Kellner and Armsby have shown that the nutrients from concentrates are worth considerably more than those from roughages. Haecker has shown that the nutrients required for the production of one pound of milk increase with the increase in richness of the milk. Another criticism of the Haecker standard is that the cows used were all small animals producing limited amounts of rich milk and therefore the standard is not quite applicable to all animals. This standard is undoubtedly low in nutrients, especially protein.

As the amount of work done in the formulating of feeding standards has been relatively limited, the computations made by Morrison perhaps approach the truth more nearly than any other standard of this type which has as yet been put forward.

The work of Kellner and Armsby has shown that feeding standards based on total digestible nutrients, regardless of their source, are inaccurate. In other words, no allowance is made for the energy used up in mastication, assimilation and other processes incident to the consumption of the feed. As a concrete example, it may be stated that Armsby has found that timothy hay, which contains 57 per cent as much digestible material as corn meal, is worth, for flesh or fat production, only 37 per cent as much as the corn meal.

In the compilation of standards of this type it was presumed that the maintenance requirements were proportional

to the live weights of the animals. There is a fallacy in this. The amount of heat lost from the animal body through radiation is dependent largely on the area of body surface, and this does not vary directly with the live weight. Again, animals of the same weight may be in different condition and so perhaps have dissimilar maintenance requirements.

Standards Based on Energy Values.—These form the newest type of standards and consequently have been computed so as to overcome some of the faults of the earlier ones. The best of the earlier standards were based on digestible nutrients, as already stated; but Kellner found that the digestible nutrients in feeds varied in the amounts of net energy they supplied to the body. He determined experimentally the net energy values for production of the digestible portions of the pure nutrients, and then applied these values to the digestible nutrients of the different feeds, and compared the computed value of each feed with the actual value as determined by feeding trials. He found that this method of computation was fairly accurate except in the case of feeds high in fiber. In this case an exceptionally large amount of energy was needed for mastication and digestion. The energy required for this purpose was found to be proportional to the amount of crude fiber present; by allowing for this, the computed value was found to be very close to the actual value.

Armsby, from his own and Kellner's results, computed a standard for maintenance which was based on true protein and net energy value. This standard allows for variation in the weights of the animals. Eckles then prepared a standard for production on the same basis, and Armsby has since proposed a similar one.

The chief objection to standards of this class is that the maintenance requirements were determined with beef animals. Perhaps beef and dairy animals do not differ much in their

maintenance requirements when of the same body weight and in comparable condition, but it would be advisable to have this work checked by experimental data from dairy animals. These standards also fail to attribute any value to the non-protein nitrogen of feeds, which is in some cases of limited value. In addition, the energy values of a large number of feeds have been determined by computation, and further direct experimental work is needed before too much reliance can be placed on standards of this type.

The best feeding standard will never furnish anything but a guide for the careful feeder. The individuality of the cow is probably the factor of greatest importance in the feeding of dairy cattle, and standards make no allowance for this. Then again, economy enters in, and the most economical ration may not always be the ration which most closely agrees with the demands of any given standard.

There are also various nutritive properties of feeds which are entirely neglected in feeding standards; for example, the content of ash and vitamines and the efficiency of the proteins. Ash or mineral matter is absolutely essential to the well-being of animals, and, though feeds vary greatly in their ability to meet the demands of animals for ash, this point has been entirely neglected in the formulating of feeding standards. Likewise, no attention has been paid to the amounts of the vitamines that are present, and these substances, though essential to the life and growth of animals, are very unevenly distributed in feeds. Moreover, though all proteins are not of equal value for nutritive purposes, feeding standards presume that they are.

A SUITABLE STANDARD

With such a large number of feeding standards to choose from, the difficulty is to find the one most suited for the calculation of rations for dairy cattle. The modification of the

Wolff-Lehmann Standard prepared by Morrison is offered in Appendix II for this purpose, as it contains only two units, digestible crude protein and total digestible nutrients, and therefore is easily used. The requirements for the production of one pound of milk varying from 2.5 per cent to 7 per cent in butter-fat content are given, in addition to the maintenance requirements per thousand pounds live weight.

FORMULATING RATIONS

In formulating rations according to any feeding standard it must be remembered that the results obtained will in most cases be only an approximation, as individual cows of the same live weight and producing ability vary greatly in their feed requirements. However, through the use of feeding standards a good idea can be obtained regarding the fundamental needs of the animals and of the general proportions in which feeds should be mixed in order to provide what the animal needs. In general practice the feeding standard is of little value to the man who thoroughly understands the business of feeding cows, but it has a distinct value in the case of the beginner, as it enables him to grasp more readily the underlying principles of good feeding practice.

Before an attempt is made to calculate a ration according to any given feeding standard a few general principles or rules should be learned. In the first place, the ration should be practical and should contain as large a proportion as possible of home-grown feeds, for the dairy cow must be looked on as the market for many feeds that cannot be profitably marketed by any other route. In this connection economy should also be considered. Where purchased feeds have to be used, those which will give the most economical returns must be selected. Variety should be provided in the ration,

and this will generally be furnished efficiently if two roughages and three or more concentrates are allowed.

Every cow should receive all the roughage she will consume, and part of it should be succulent. On the average, dairy cows will consume 25 to 35 pounds of corn silage and 10 to 15 pounds of a legume hay per thousand pounds live weight daily. The roughage of the ration is generally used to provide the maintenance portion of the ration for the animal, while a grain ration is provided over and above this, to be used for productive purposes.

As a general rule, 20 to 30 pounds of dry matter will be required daily per thousand pounds live weight, and about two-thirds of this should be provided by the roughages and one-third by the concentrates. The amount of concentrates fed will depend largely on the milk production. As a general rule, 1 pound of grain will be needed for each 3 to 4 pounds of milk produced, depending on the amount and richness of the milk. Another method of determining the grain ration is to allow 7 pounds of grain for each pound of butter fat produced.

When a ration is calculated in accordance with a feeding standard it is not generally necessary to give great attention to the nutritive ratio, as that will automatically take care of itself; but it may be said that the nutritive ratio required in the ration of a milking cow will generally be between 1 : 5 and 1 : 7.

As an example of a ration to be made up according to the feeding standard given in Appendix Table II, take the case of a 1200-pound Holstein cow with a daily production of 40 pounds of milk containing 3 per cent of butter fat.

The maintenance requirements for this cow can be obtained by proportion from Appendix Table II. The cow is not an exceptionally high producer, and, presuming that the cost of protein in feeds is about normal, she can be given about

the average requirements for production, or .052 of a pound of digestible crude protein and .271 of a pound of total digestible nutrients per pound of milk produced. Her total daily requirements of nutrients would then be:

	Digestible Crude Protein, Pounds	Total Digestible Nutrients, Pounds
For maintenance	.84	9.51
For production	2.08	10.84
Total	2.92	20.35

Now that the requirements of the cow have been found to be 2.92 pounds of digestible crude protein and 20.35 pounds of total digestible nutrients a ration must be found which will fulfill these requirements and at the same time be practical. The nutrients available in the various feeds can be found in Appendix I, which gives the amount of digestible nutrients available in various feeds.

For the roughage part of the ration a reasonable allowance would be 35 pounds of corn silage and 12 pounds of alfalfa hay. These feeds will provide the following nutrients:

	Digestible Crude Protein, Pounds	Total Digestible Nutrients, Pounds
35 lbs. corn silage	.39	6.20
12 lbs. alfalfa hay	1.27	6.19
Total	1.66	12.39

This leaves 1.26 pounds of digestible crude protein and 7.96 pounds of total digestible nutrients to be furnished by the

grain ration. A grain mixture can be found, by trial, which will supply this, for instance:

	Digestible Crude Protein, Pounds	Total Digestible Nutrients, Pounds
4 lbs. corn meal	.28	3.35
3 lbs. ground oats	.28	2.10
2 lbs. wheat bran	.25	1.22
2 lbs. linseed oil meal O. P.	.60	1.56
Total	1.41	8.23

This ration does not exactly coincide with the requirements of the standard, but is sufficiently close to it for practical purposes, as there is a difference of less than 1 pound in the amount of total digestible nutrients, and a difference of only .25 of a pound in the digestible crude protein provided by the ration and that called for by the standard. In addition, it contains a good selection of feeds which are palatable, give plenty of variety and are largely home-grown.

CHAPTER IX

THE BALANCE OF NUTRIENTS

In common parlance the balance of nutrients in the ration is considered as referring to the relationship which exists between the digestible crude protein, on the one hand, and the digestible carbohydrate equivalent, on the other hand or, in other words, it is looked on as synonymous with the term nutritive ratio of the ration. It is true that these terms are synonymous but, considered in a broader sense, the term balance of nutrients includes several other factors of great importance, such as the ash content of the ration, the presence or absence of vitamines and the quality of the proteins. Some of the factors which affect the balance of nutrients required by the cow need consideration.

To a considerable extent the main classes of nutrients—proteins, carbohydrates and fats—can be used interchangeably in the animal organism; for example, proteins can be used for the building up of body fat, and the functions of the fat of the ration can be almost completely taken over by the carbohydrates. In spite of this, however, no one nutrient, or group of nutrients, should be used to the exclusion of any other if the best results are desired.

Proteins are absolutely essential for the repair of body tissues and the formation of the nitrogenous constituents of the fetus and the milk, although most of the other duties performed by proteins can be taken over by the carbohydrates and fats. It does not pay, however, to feed just the minimum amount of protein required for these vital processes, as addi-

tional protein appears to have a stimulating effect on general metabolism and consequently on milk production. On the other hand, proteins are, as a rule, much more costly than are the other nutrients, and therefore too much protein in the ration will render milk production uneconomical. It is evident, therefore, that a balance must be preserved between the nitrogenous and non-nitrogenous constituents of the ration, and the exact balance to be used must be determined by the requirements of the individual animal and the relative costs of the various nutrients.

Similarly, carbohydrates and fats can be used interchangeably for certain purposes, and yet a proper balance, from the nutritional and economic standpoint, should be maintained between those two classes of nutrients.

Feeding standards recognize only the main classes of organic nutrients, no attention being paid to the ash constituents of the feed; and yet the ash is one of the very important materials. One of the main reasons for the neglect to mention ash requirements in feeding standards is that, in general ordinary farm rations contain enough mineral matter to meet the requirements of the dairy cow. Again, very little work has been done to determine the actual ash requirements of farm animals. From what work has been done it may be said that the requirements of dairy cows for some of the more important ash constituents vary widely, but perhaps an average of 1 ounce of calcium and one-third of an ounce of phosphorus is required for the daily maintenance of a cow weighing 1000 pounds, while, in addition, 1 ounce of calcium and one-half ounce of phosphorus will be required for each 20 pounds of milk produced.

This demonstrates the small ash requirement of the dairy cow. Although small, it is very important, and when sufficient ash for production is not present the cow will draw on her own body for the necessary constituents until her reserve

supply becomes exhausted, when she will decline in milk production.

If a cow is being fed a ration that is deficient in one or more of the necessary nutrients she will draw on her own body for the supply of these nutrients necessary for milk production, and when this supply is exhausted she will decrease in production. Many cows are doing this. They produce milk in fair quantities for a few months after calving, not because their ration is composed of ear corn, timothy hay and cornstalks, but in spite of it. However, after they have drawn upon their bodies as long as they can for the nutrients necessary for milk production they rapidly decline in their yields of milk. When they are dry they again store up in their bodies nutrients to be used for milk production during the next short lactation period.

A proper balance of the nutrients—protein, carbohydrate, fat and ash—should be maintained in the ration; but just what that balance should be is rather difficult to state. The balance of nutrients required by a cow depends on a considerable number of factors.

AGE

Young cows are still growing while they are producing milk, and their ration should provide the nutrients required for this growth. Thus, a ration for milking heifers will require more protein and ash, in proportion to the other constituents, than will a ration for older cows, as protein and ash are the constituents specially demanded foı the purposes of growth.

SIZE

The influence of the size of the cow on the nutritive ratio required in her ration is rather a complicated one. Large cows consume less feed and produce less milk and butter fat

per hundred pounds live weight than do small cows, though the large cows produce most milk and butter fat per hundred pounds of feed consumed. As the small cow produces most milk per hundred pounds live weight, her maintenance requirements constitute a relatively smaller portion of her total feed requirements than is the case with the large cow. Consequently the small cow, other things being equal, will require a narrower nutritive ratio in her ration than will the large cow, as relatively less protein is needed in the maintenance part of the ration than is required in that part of the ration used for productive purposes. One influence which tends to counteract this is the fact that the small cow requires more nutrients per hundred pounds live weight and a wider nutritive ratio in the ration for maintenance than does the large cow, but this variation is not great enough to nullify the proposition stated.

CONDITION

The condition of an animal has an influence on the amount of nutrients required per thousand pounds live weight for maintenance. It was found at the Iowa Station that animals in high condition required more nutrients for maintenance per hundred pounds live weight than they did while in low condition, but the animals in low condition required relatively less protein. In other words, they needed a ration of wide nutritive ratio, this probably being due to an attempt on their part to bring the condition of the body back to normal through the use of carbohydrates and fats for the formation of body fat.

Dairy cows should not be kept in low condition, as they will not give maximum production for a long period under such conditions. They should receive a liberal allowance of carbohydrates and fats in order that their stores of nutrients may

be replenished and they may then be enabled to produce for a longer period.

Conversely, animals in high condition should be fed a ration of narrow nutritive ratio in order that the further production of body fat may be prevented as far as possible, since excessive condition is not conducive to maximum milk production.

YIELD OF MILK

The law of diminishing returns applies to the production of milk, as it does to practically every other form of productive activity. The greater the milk production, the greater will be the amount of nutrients required for the production of each pound of milk; for example, 40 pounds of milk per day will require more than twice as much nutrient material for its production as will 20 pounds per day. It is very probable also that an increase in milk production will call for more than a proportional increase in the amount of protein, as increased activity of the epithelial cells will call for more material for the replacement of katabolized protoplasm; consequently, the higher the milk production of a cow is, the narrower will be the nutritive ratio required in the ration.

QUALITY OF MILK

The richer the milk the greater will be the amount of nutrients required for the production of each pound. The protein content of milk does not increase as rapidly as does the fat content; that is, more milk protein per pound of fat is produced in poor milk than in rich milk. From this it is evident that on the whole the protein requirements for milk production will very probably increase less rapidly than the energy requirements as the milk becomes richer. There will be some increase, however, due to the fact that the epithelial cells of an udder producing 30 pounds of 4 per-cent milk will

do more work than those of an udder producing 30 pounds of 3 per-cent milk. Very probably a narrower nutritive ratio is required in the ration when poor milk is being produced than when rich milk is being secreted.

STAGE OF LACTATION

As lactation advances more feed will be required to produce 100 pounds of milk than was required in the earlier stages of lactation. This refers to the whole ration, for both maintenance and production. As the amount of milk produced per hundred pounds live weight decreases with advance in lactation, the total amount of feed eaten per hundred pounds of milk produced must increase. It is very probable also that the exact requirements for production alone increase with the advance in lactation, because of the fact that the impetus to milk secretion is decreasing.

In the later stages of lactation the cow is usually pregnant; and though work at the Missouri Agricultural Experiment Station has shown that very little feed is required for the growth of the fetus, it is probably best to provide for the cow at this stage a ration with a good supply of protein and ash. At the same time, however, it will be necessary to build up the body reserves of the animal, and the desired increase in weight can usually be obtained by the liberal use of carbohydrates and fats. Consequently the ration at this stage will have a wider nutritive ratio than that used earlier in the period.

INDIVIDUALITY OF THE COW

Individual cows vary not only in the total amounts of nutrients, but also in the relative proportions of the various nutrients which they require for the purpose of maintenance and production. Cows of the same weight, producing equal

quantities of milk of the same quality, will vary in their requirements. Such variations are due to the "individuality" of the animals and cannot be accounted for or controlled. The only solution for this problem is to cater to the needs of the individual cows, as far as possible.

CHAPTER X

CHARACTERISTICS OF A GOOD RATION

A FEEDING standard is but a guide which indicates the approximate amounts of the various nutrients required by an animal. In compounding rations for dairy cattle many factors which are neglected by feeding standards must be taken into consideration, the majority of which are simple and easy to control, yet attention to them will be of great importance in determining the relative economy of milk production.

PALATABILITY

Though the existence of palatability is seldom questioned, its definition or explanation is by no means simple. The palatability of a feed, though not determined, so far as is known, by the relative amounts of proteins, carbohydrates and fats present, has a decided influence on the economy of milk production. Likewise, though it has no bearing on the inherent digestibility of the nutrients present, it may probably have an appreciable effect on the utilization of those nutrients. The palatability of feeds is due to the presence of aromatic substances which give to the ration an aroma and flavor that is pleasing to the cows.

The secretion of the digestive juices is to a certain extent stimulated by nervous influences, and there is a probability that palatability and other factors inducing such secretion may thus cause indirectly a change in the amount of material

digested. This perhaps holds true to a marked extent only when feeds are very unpalatable. Even if palatability has no influence on digestion, cows must be given feeds that suit their tastes if they are to do their best work, as a cow will not eat all she needs for maximum production if her ration is unpalatable. If feed consumption is not maintained at a high level, milk production cannot be as copious as it should be.

Feeds vary widely in their palatability and there are also considerable variations in the palatability of different samples of any one feed. Likewise, cows vary in their likes and dislikes regarding feeds, and individual cows may also vary in their tastes from time to time.

It is not possible to rank feeds absolutely according to their palatability, but it may be said that as a general rule the succulent feeds and the leguminous hays are among the most palatable roughages while the cereal grains are perhaps the most palatable concentrates. The by-products used as concentrates are in some cases not very palatable. There are an exceedingly large number of exceptions to this, however; for example, green sweet clover is generally unpalatable to animals when first fed, though it is both a succulent and a leguminous feed; rye, though a cereal grain, is not very palatable; while wheat bran and linseed-oil meal, by-products used as concentrates for dairy cattle, are very palatable.

The animals find certain feeds unpalatable at first, but begin to like them when they have been fed for some time. This is very frequently true of such feeds as gluten feed and cottonseed meal, which are generally not relished until the cows have become accustomed to them. Many feeds that are relatively unpalatable can be advantageously disposed of by feeding in a mixture with other concentrates. Care must be taken, however, to include only a limited quantity of the unpalatable feeds in the mixed ration.

The method of preparation of a feed has some influence on its palatability, cracked corn and ground oats being generally considered more palatable than the whole grains. This cannot be laid down as an absolute rule, however, as a great deal depends on what the animals have been accustomed to. An animal may show a preference for some preparation with which it is familiar and may find a new preparation unpalatable for a time, until the animal acquires a taste for the new feed which it may eventually relish more than it did the first preparation. Though ground grains are generally more palatable to milk cows, whole grains are preferred by young calves.

The condition of a feed determines its palatability to a large extent. Badly weathered hay and moldy grain are quite unpalatable, and great care must therefore be taken to have all constituents of the ration in good condition if the best results are to be obtained from the feeding operations.

The individual peculiarities in the tastes of the cows are not always easy to cope with, but they must be catered to if high production is desired. Feeds that are usually palatable may at times be eaten but sparingly or even absolutely refused by some cows. A pure-bred Holstein cow, Lucy Duchess DeKol, at one time owned by Iowa State College, may be taken as an example. Beginning a few days after freshening, she was fed 1 pound of ground oats daily in her ration, and in about one month she was receiving 14 pounds of grain daily; of this, 3 pounds were ground oats. It was noticed that she was refusing to eat all of her grain, but was trying to get the grain of her neighbor. Her neighbor was receiving a very similar allowance of concentrates but no ground oats. The cow under consideration was decreasing in milk flow, and it was suspected that the presence of the ground oats was rendering her ration unpalatable. The 3 pounds of ground oats was replaced by other feeds and she immediately started to clean

up her grain ration and to increase in production. She evidently did not relish ground oats at that time, though it is generally considered to be very palatable and she had been consuming it to the extent of 4 pounds per day for some time previous to freshening.

Palatability is based to some extent on the needs of the animal, but it is also governed by her past experience. If a cow has been overfed on any feed it is sometimes unpalatable to her for a long time afterwards. A pure-bred Guernsey cow at Iowa State College, Imported Rouge II of the Brickfield, was at one time overfed on gluten feed and for several years she showed a lack of tolerance for it. Later, however, she would consume 2 pounds of it in her daily ration as she had again acquired a taste for it.

When a cow appears not to relish her grain allowance it is sometimes difficult to ascertain just which constituent is the cause of the trouble. A suitable method of determining this is to give the cow an opportunity of cleaning up all she wants of her regular grain ration and then offer to her separately small quantities of the individual feeds of which it is composed. If a feed offered is palatable she will very probably consume it, whereas if it is unpalatable she will refuse it.

Cows will not clean up feeds that are unpalatable to them, and as they very probably do not utilize unpalatable feeds to the greatest advantage even when consumed, it can be seen that unpalatable feeds are unprofitable for two reasons. In some cases cows that are considered poor feeders and low producers can be rendered more productive by changing their feeds so as to provide them with a more palatable ration. This emphasizes the necessity of individual feeding where large records are aimed at. It shows that lack of care in the selection of the feeds for the ration of the milking herd may result not only in a waste of high-priced feeds, but also in lowered milk production. Upon the ability of the feeder to

determine the most palatable ration for each of his animals depends the size of the records of the individuals in the herd.

VARIETY

The dairy cow, unlike the beef animal, is on feed for many successive long periods of time, and as the best production can be obtained only by good feeding, it is necessary that everything possible be done to keep the cow on feed. Palatability is an important factor in the feeding of dairy cows, and closely linked with it is variety in the ration. Variety does not mean a mixture of feeds from the same plant source, such as corn silage, corn stover, corn meal and corn gluten feed, but refers to a combination of feeds from distinct sources, such as corn silage, clover hay, rolled barley, wheat bran, ground oats and linseed-oil meal.

Frequent or radical changes in the ration are not to be recommended as they tend to throw the cow off feed and cause digestive troubles. Rations composed of a limited number of constituents may become unpalatable when fed for a long period, and rations composed of a fair number of different feeds are therefore to be recommended. Even such rations, however, occasionally become unpalatable or unsuited to the needs of the cow, but their alteration is an easy matter. The proportions of the various constituents present can be changed, one or more constituents left out, or new constituents added or used to replace constituents already present. In this way the rations can be kept in accord with the needs of the cow for maintenance and production and yet be palatable at all times. Slight changes in the proportions of the constituents of a ration will usually do more towards increasing its palatability than will radical changes in the whole ration.

For good producing cows two roughages should be provided, preferably corn silage and a legume hay, and as a rule three or four constituents should be included in the grain

ration. In the corn belt dairy cattle rations too frequently consist of corn and corn products with perhaps one roughage from another source, and comparable conditions are to be found in other regions. Such rations are not economical for milking cows.

Variety in the ration, with occasional slight changes in the constituents of the concentrate allowance, will very frequently be all that is needed to keep the ration palatable and the cow producing to her maximum capacity. In other cases, especially with high producers. it will occasionally be found advantageous to replace the grain ration with a bran mash. Such a mash is composed largely of wheat bran moistened with warm water, but oil meal and salt may be added. This gives variety, stimulates the appetite, has a laxative, cooling effect on the digestive system, and can be highly recommended when cows become sluggish in their feeding.

Recent work has shown that other advantages are to be obtained from variety in the ration. The proteins are built up of amino-acids, but the proteins from different plant sources do not all contain the same amino-acids. As the cow needs a considerable number of amino-acids for the building up of her body and milk proteins and as some of the essential ones are absent or deficient in certain plant proteins, variety in the ration is essential if the cow is to be provided with all the necessary amino-acids. In addition, the vitamines are unevenly distributed in the various feeds and, their presence being essential to the welfare of the animal, it is necessary that a ration of varied character be supplied so that the necessary vitamines may be provided in sufficient quantities.

The problem of supplying variety in the ration of the dairy cow is not a difficult one, as a general rule, and attention to this factor will be well repaid with additional milk yields and more economical production.

BULK

The dairy cow, like other ruminants, has a large, roomy alimentary tract, especially adapted to the handling of bulky feeds, and she can handle a bulky ration much more efficiently than one of too concentrated a character. There are two main reasons for this. Bulky feeds are easily regurgitated and so are more thoroughly masticated and better prepared for further digestion than are concentrated feeds. In the digestive tract of the cow, heavy or concentrated feeds—those that are not light or bulky—tend to form compact masses which resist the action of the digestive fluids and so do not yield all the nutrients which they are capable of providing. In some cases they may even cause serious digestive disturbances.

When plenty of bulky feeds are present in the ration the best digestive action is obtained, as the hay and other bulky materials keep the particles of grain and other concentrated feeds apart and allow them to be thoroughly acted upon by the digestive juices.

A good indication of the necessity of a ration of considerable bulk for the dairy cow was obtained at the Iowa Station with two cows on maintenance trials. A ration of uniform composition was fed throughout; when the cows were being maintained in high condition the average coefficient of digestibility for the dry matter of the ration was 66.94 per cent, while it was only 59.77 per cent when they were being maintained in low condition. The weight of the ration was 28.6 per cent greater when the animals were in high condition; evidently the increase in the total bulk of the ration allowed the cows to utilize it more completely.

As the cow is preëminently a handler of roughages it is usually most economical to allow her to consume as much as possible of the rough feeds grown on the farm. This not only forms a market for home-grown feeds that are cheaply pro-

duced and difficult at times to market to advantage, but the presence of the bulky feeds in the ration allows her to utilize the concentrates fed more efficiently than she would otherwise. Practical experience has shown that the best results will be obtained when the roughages, silage and hay, as a rule, provide about two-thirds of the dry matter of the ration and the concentrates about one-third. With high-producing cows the amount of dry matter in the grain fed sometimes exceeds that given as roughage, but long-continued feeding by such methods cannot be endorsed, as it is an enormous strain on the digestive system of the cow and a general collapse in digestive powers and producing ability will result.

In the cases where a heavy grain ration is being fed, and even frequently when the grain allowance is not so liberal, it is advisable to have some bulky constituents in the grain ration in addition to the roughages. This can be supplied in many sections by such feeds as corn-and-cob meal, wheat bran and ground oats. Cottonseed hulls are occasionally used for this purpose in some localities. The particles of cob present in corn-and-cob meal have little, if any, nutritive value, but their mere physical presence keeps the particles of corn apart, thus allowing more thorough digestion and utilization of the nutrients in the particles of corn. The action of the cob is almost entirely mechanical, but it is of such a nature that it renders corn-and-cob meal of about equal value to corn meal, on the basis of weight, for feeding purposes with dairy cows when other bulky constituents are lacking in the grain ration.

Where such light and bulky feeds as ground oats and wheat bran are too high-priced to give economical returns when fed to dairy cattle, a good method of obtaining bulk in the grain ration of high-producing cows is by the addition of alfalfa or clover hay which has been cut into quarter-inch lengths. The hay should be cut daily so that it will remain

fresh. After moistening with steam or warm water, just sufficient to soften the stems, it is mixed with the concentrates.

A very good indication of the relative bulk of concentrated feeds can be obtained from a study of their weights per quart. An idea of the wide variations which occur in these weights can be obtained when it is noted that corn and cottonseed meal each weigh 1.75 pounds per quart, while a quart of wheat bran weighs only .55 pound or less than one-third as much.

SUCCULENCE

Succulent feeds have a very beneficial effect on milking cows and are essential to the most economical production of milk. The benefits to be derived from succulent feeds are due to a considerable extent to the fact that they render the ration palatable, are laxative in nature and provide part of the large amount of water required by high-producing cows.

Good pasture grass is the best succulence for dairy cattle, and in the early part of summer it will, as a rule, provide all the succulent feed they require. In the later part of summer, when the pastures in many sections begin to dry up, soiling crops or silage should be used to provide additional succulence. In winter, silage forms the most economical succulence, though it can sometimes be advantageously supplemented with roots or dried beet pulp, which is soaked before feeding. Some form of succulent feed should be included in the ration of the dairy cow throughout the year.

EFFECT UPON THE SYSTEM

To work profitably, every cow must at all times be in perfect health; consequently the feeds selected must be such as will keep her digestive tract in its best working condition and also maintain her in general good health. The cow will do her best work when her ration is laxative in character, and

so the ration as a whole must be one that tends to counteract constipation.

Succulent feeds, as already mentioned, have a beneficial effect on the digestive system and general condition of the cow. Alfalfa and clover hays are also slightly laxative in effect and for this, as well as other reasons, are to be preferred to such feeds as timothy hay, oat straw and corn stover, which are constipating in action.

Feeds that are moldy or in other ways spoiled tend to cause digestive troubles. In addition, they may cause derangement of health or may even be absolutely toxic, and so should be avoided. The dangers of moldy feeds, however, are not as great with cattle as with horses.

Some feeds have specific effects on the digestion and general health of the cows; in compounding a ration for a dairy animal it is necessary, therefore, to see that the bad effects of any of the individual constituents of the ration are counterbalanced by the good effects of other feeds. Cottonseed meal has a constipating effect, and when fed in too large quantities may even become toxic. It should never be fed to cows near the end of pregnancy nor to calves under weaning age. Feeds such as wheat bran and oil meal have a laxative and cooling effect and should, as a rule, be fed when constipating constituents are included in the ration. They are especially valuable where no succulent roughage is available. Care must always be taken in compounding a ration to see that it is laxative in character and that no feeds which might produce undesirable results are fed in large amounts.

EFFECT UPON THE PRODUCTS

Milk and butter fat are the marketable products of the dairy farm, and care must be taken to avoid any deleterious effects which might be produced on those materials by the feed given to the cows.

It has been found that, as a rule, the feed does not have any influence on the flavor of milk, provided the feeding is carefully done, even though it has frequently been stated that silage imparts a disagreeable flavor to milk. If the feeding be done carelessly this is true, but if proper methods of feeding be pursued and proper precautions be taken to prevent the contamination of the milk, no deleterious effect will result. The same applies to rutabagas, cabbage and similar feeds. If silage or roots are fed just before milking, or unused feed is allowed to remain in the mangers, the milk may have a disagreeeable odor, especially if it is not removed from the barn immediately after milking.

Garlic and other weeds will impart a disagreeable odor to the milk when they are consumed by the cows. This is due to volatile substances present, which are absorbed from the alimentary tract, carried to the udder by the blood and eliminated in the milk. Such substances do not affect the flavor or odor of milk for any considerable length of time after they have been eaten.

Certain feeds influence, to a limited extent, the chemical and physical characteristics, and consequently the consistency, of butter. Linseed-oil meal, peanut meal and gluten products have a tendency to produce a soft, salvy butter of inferior flavor, while cottonseed meal renders the butter hard and tallowy. These feeds do not produce marked effects unless fed in too large quantities, and by properly balancing the constituents of the ration such influences can be minimized. The feeding of cottonseed meal in the summertime is often advisable, as the butter produced at this season is generally soft and cottonseed tends to make it firmer.

PART IV

THE FEEDING STUFFS

CHAPTER XI

SILAGE

The ensiling of crops is not new, but the present-day silo is of comparatively recent origin. The silo makes possible the complete utilization of a large amount of succulent forage that would otherwise be wasted or only partially used, decreases the labor of winter feeding, makes available a supply of good feed at seasons when it would otherwise be scarce, acts as a storehouse in which excess feed from one year can be carried over to another, and ultimately increases the live-stock-carrying capacity of the farms. The increase in the number of silos within the last decade has been remarkable, but a realization of their true value will further augment their numbers.

CORN SILAGE

Corn silage is an essential feed on all dairy farms in the corn belt. Without it the largest and most economical milk production cannot be obtained. Corn is the best silage crop for several reasons: it gives good yields, packs well in the silo, is rich in starch and other non-saccharine carbohydrates, thus insuring silage with a moderate acidity, and has a relatively low protein content, thus reducing to a minimum the danger of putrefactive changes. The main acids present in silage are lactic and acetic, and they tend to impart to it a pleasant aromatic odor, thus increasing its palatability.

The best corn to grow for silage depends on the locality, and the best silage is made from corn which will practically mature where it is grown. Rank southern corn, while yielding more in total weight of green feed per acre, does not generally produce more when considered on a dry-matter basis. It does not make as palatable nor as desirable a silage as do some of the less luxuriant types.

While practical men are not all agreed as to the best time to cut corn for silage, the general practice is to do it soon after the corn begins to dent and the lower leaves begin to dry up. In the northern sections the aim is to cut the corn just before frost, without much regard to its maturity.

The degree of ripeness at which the crop is cut has a great influence on the yield and quality of silage produced. If the ensiling is done too early the maximum yield of nutrients will not be obtained and, owing to the large amount of water and soluble substances present, the fermentation will be excessive, much valuable feeding material will be lost, a poor quality of silage will result and the large amount of water present may even cause the silo to leak. If the cutting is delayed too long the yield of dry matter will be at a maximum, but owing to the maturity of the corn there will be a high fiber content and too little moisture to insure good packing; large amounts of air will be present, and the contents of the silo will become moldy and perhaps rot, unless water is added at the time of filling. Moldy silage is not only undesirable but sometimes even dangerous to stock, although this danger is not so great with cattle as with horses. The yield of corn silage per acre is variable, but it may generally be assumed that about 1 ton of silage can be expected for each 5 bushels of corn that could be obtained.

The following figures adapted from "The Soft Corn Predicament," by Evvard, of the Iowa Agricultural Experiment Station, illustrate well the facts mentioned:

TALBE XII

Percentage Yield of Nutrients from an Acre of Corn at Different Stages of Growth

Stage of Growth	Dry Matter, Per Cent	Crude Protein, Per Cent	Nitrogen-Free Extract, Per Cent	Crude Fiber, Per Cent
Ready to shock	100	100	100	100
Well dented	95	95	96	92
In the glaze	86	82	86	88
In the milk	66	79	61	78

That the use of the silo makes possible the most efficient harvesting of the corn crop is shown by results from the Wisconsin Agricultural Experiment Station. During a period of four years it was found that when the corn crop was dried in the shock there was an average loss of 23.8 per cent of the dry matter and 24.3 per cent of the crude protein, whereas when the corn was made into ensilage the respective losses were 15.6 per cent and 16.8 per cent. This shows a considerable conservation of the valuable food nutrients. Then again, when the crop has been put in the silo all of it will be consumed by the animals, but when the corn has been shocked the stock will refuse a large part of it.

Though good succulent corn is to be preferred for the making of silage, fairly satisfactory feed can be made in the silo when this is not obtainable; by this means a corn crop which has been damaged by drought or frost, and which otherwise would be wasted to a large extent, can be made into a valuable forage. Such material is not necessarily poor or dangerous as a feed. It contains the same amount of nutrients as it did immediately before it was damaged, though, of course, less than if it had been allowed to come to the proper stage of development. If it is ensiled as soon as

possbile after it is damaged it will come out of the silo in good condition. If it has been allowed to dry out, however, water should be added as it is being put into the silo, as this will aid in the packing process and give the necessary succulence.

Corn fodder that has been dried in the shock can also be made into good silage if plenty of water is added to moisten it. Though not quite as palatable as the silage made from the fresh, green forage, it gives good results and will be more thoroughly utilized than would dry fodder. Similarly, corn stover can be rendered more valuable as a feed by being put in the silo, though, of course, the absence of the ears lowers its feeding value.

The amount of water that should be added in the ensiling of fodder or stover varies, but it has been found that as a rule about 1 pound of water will be required for each pound of dry forage. According to recent Illinois Agricultural Experiment Station results, slightly less water gives a more palatable silage. The quality of the silage is largely affected by the amount of water added. More water than is actually required does not harm the feed, though it makes it heavier to handle without any apparent benefit. Good results have been obtained from the ensiling of fodder at the Missouri Agricultural Experiment Station and other Agricultural Experiment Stations and by practical dairymen, and if future work confirms this it may become a common practice to fill silos twice or oftener during the year.

A conservative estimate fixes the value of the silage at from 10 per cent to 20 per cent over the equivalent dry fodder, though some put it much higher.

Sometimes when silos are filled at the usual time the corn is husked, but this is not to be recommended. At the Vermont Agricultural Experiment Station it was found that the yield of $1\frac{1}{4}$ acres treated by this method was required to produce silage of the same value as that from an acre of unhusked

corn. Where the corn has been husked, a heavier grain ration must be fed; there is, therefore, no advantage in husking and then ensiling the crop.

Poor silage, as a rule, results from one of two causes. First, poor packing of silage, with plenty of moisture present results in the entrance of air and rotting, while in the second place silage that is too dry will not pack well and as a consequence it will become moldy. Good packing at filling time directly influences the quality of the silage.

Great variations are to be found in the estimates given as to the cost of producing a ton of silage. The cost varies greatly with individual cases, depending largely on the size of crop obtained and the cost of labor. The cost of producing silage is sometimes figured on the basis of the corn it contains—the market value of the corn being used. This really gives not the cost of production of the silage, but the sum that could have been obtained by selling the corn at the elevator in preference to putting it in the silo. This latter method of determining the value of the silage can frequently be used advantageously if some allowance is made for the fodder contained.

The increase in the corn-canning industry has resulted in the production of a large amount of cannery refuse which is frequently allowed to go to waste, but which can be satisfactorily used as silage. At some canneries this refuse is put in silos while at others it is simply piled up. The greatest conservation is obtained where the silo is used, but even the piled-up waste can provide a large amount of good feed, though the outside material will be spoiled. Where the spoiled ears and the cobs are not put in with the remainder of the waste products from the sweet-corn cannery, the refuse has a fair feeding value. It was found at the Iowa Agricultural Experiment Station that 1 ton of this material, with the addition of 5 bushels of corn, had a value about equivalent to

that of 1 ton of good corn silage. Where the spoiled ears that cannot be used for canning are put in with the rest of the waste material, a silage of somewhat higher feeding value will be obtained. This indicates that, by the proper utilization of all the cannery refuse by means of the silo, a very valuable addition to the supply of succulent forage for winter feeding would be obtained in many sections.

The value of corn silage as a forage depends largely on its succulence, bulk, palatability and the beneficial effect it has on the digestive tract of the animal. In effect it is laxative and cooling. These are the essential characteristics of a good ration for a dairy cow and they make silage an excellent feed for milk production. In addition, silage from unhusked corn contains about 5 bushels of grain per ton.

Silage should be fed to all classes of dairy cattle. The only precautions that have to be taken are in the feeding of the bull and the young calves. Too much silage causes the bull to become sluggish, awkward and slow at breeding. However, a limited amount is desirable. Silage is not desirable for young calves as it ferments readily and thus may cause digestive disturbances.

Silage should be supplemented not only with concentrates but also with a legume hay. Growing stock and milk cows need all the silage they will consume, in addition to their hay and grain. Milk cows, as a rule, take $2\frac{1}{2}$ to $3\frac{1}{2}$ pounds of silage per hundred pounds live weight per day.

When the cows are turned out to pasture in the spring the milk yield invariably increases; this is due largely to the palatable, succulent nature of the pasture. This initial rise is not a full measure of the value of pasture, however, as it puts the cows in condition for continued milk production. The feeding of silage in winter renders available many of the advantages of pasture, as the essential characteristics of the two are similar.

Silage, though of greater value in winter, can be used to considerable advantage in summer when the pasture is short and dry. The feeding of silage in the barn, during the hot, dry weather of summer, is an excellent method of supplementing scant pasture.

The feeding of silage, though not a difficult matter, should be done with care, or trouble may arise. The silo should be of such a diameter that sufficient feed can be taken out each day to prevent decomposition of the top layer. This is especially true in the summer, and if a silo is erected for summer use only, it should be of smaller diameter than the winter silo. In winter the silage will keep well if at least 2 inches per day are removed for feeding purposes, but in summer it must be removed twice as rapidly. In general, the winter silage-feeding period averages about two hundred and twenty-five days in duration, and as 2 inches is the smallest depth of silage that should be removed per day, the total depth of the silage in the silos should be at least 36 to 38 feet at the beginning of the winter feeding of silage.

At one time it was thought that good milk could not be produced when silage was fed, but this is incorrect. Milk will rapidly take on a silage odor if it is given the opportunity. If the silos are shut off from the barn, the silage fed after milking, the amount limited to what will be cleaned up in a short time, and the milk removed from the barn as soon as it is drawn, there is no danger of having a silage odor in milk. Bad odors of any kind in milk are, as a rule, due to carelessness. A test conducted by the Illinois Agricultural Experiment Station regarding the flavor of milk from silage-fed and non-silage-fed cows gave results very favorable to the milk from the cows that had received silage. Out of three hundred and seventy-two people to whom the milk samples were submitted 60 per cent preferred the milk from the silage-fed cows, 29 per cent preferred the milk

from the non-silage-fed cows, and 11 per cent expressed no preference.

Even at the present time it is sometimes said that silage causes the teeth of the cows to decay, brings about digestive troubles and may induce abortion. These statements are incorrect. Silage does not cause teeth to decay, and unless it is badly molded or decayed or suddenly fed in too large quantities, it will not cause digestive troubles. The only way in which silage could induce abortion would be as a result of some of the improper feeding methods just mentioned.

OTHER SILAGE CROPS

Corn is the paramount silage crop on account of its adaptability for this use and the wide area over which it is grown. Other crops are used for silage to a limited extent, in some cases where corn cannot be successfully grown and in others where attempts have been made to utilize by-products that would otherwise be wasted.

Non-Leguminous.—Of the non-leguminous crops used for silage, the sorghums are perhaps the most important; both the sweet and grain sorghums are used for this purpose. They are of the greatest value in the drier sections of the country, though of little importance in the corn belt. Under such conditions they give good yields and provide a very palatable silage which is somewhat below corn silage in feeding value. At one time it was thought that the sorghums would give a silage of too great acidity, but this is incorrect. Kafir corn and amber cane appear to be the only two sorghum silages which have been directly compared and the former was of somewhat higher feeding value.

Some work has been done in the west on the use of sunflowers for silage, and although fair results have been obtained, the feed is not as palatable nor as valuable for milk production as is corn silage. To make the best silage, the sunflowers

must be cut when about one-third of the crop is in bloom and chopped finely to insure proper packing. The silage made in this way is perhaps of about the same value as that made from immature corn. The possible future for sunflower silage lies in some of the regions where corn cannot be successfully grown.

The lesser cereals, such as oats and rye, have been used to some extent for silage, but they do not provide as valuable a forage as does corn. The yields are small and the crops must be cut early to prevent the presence of too large an amount of fiber. In addition, good packing is necessary to prevent large amounts of air from lodging in the hollow stalks and resulting in undesirable fermentations. Similarly, grass crops are occasionally used for silage where the locality or season is too damp to render the making of good hay possible. Such practices are quite infrequent in this country.

A few materials of relatively high water content, such as beet pulp, beet tops, apple pomace and prickly pear, are occasionally used for silage purposes. Though the silo renders the utilization of these materials for feeding purposes possible, they do not furnish the best quality of silage. This is largely due to the great amount of water present and the difficulty of preventing deleterious fermentations. The use of such materials for silage must always be limited though at times it may be recommended as a conservation process.

Leguminous.—Many attempts have been made to ensile such leguminous crops as clover, alfalfa, soybeans and cowpeas, but the results have not been very satisfactory. The presence of a considerable amount of protein gives a good basis for the occurrence of a large amount of putrefaction, while the absence of a sufficient quantity of soluble carbohydrates limits the formation of the organic acids which exert a preservative effect on corn silage. There consequently appears to be little future for the use of legumes as silage

crops, though it is the practice in some sections to use the pea-vine waste from pea canneries for silage purposes. This is simply a conservation process which renders possible the use of feed which would otherwise be wasted.

Mixed.—It is recognized that crops, such as corn and the sorghums, which contain a fair amount of soluble carbohydrates, are most easily preserved as silage. One of their disadvantages, however, is that they do not contain quite as much protein as might be desirable. Consequently, attempts have been made to combine leguminous crops which are not easily preserved with some of the non-legumes and so get a silage of good keeping quality and fair protein content.

Corn has been ensiled with both soybeans and cowpeas, and satisfactory results have been obtained in many cases, though occasionally less favorable reports are given. More information on this problem is needed from both the practical and the experimental standpoints. Sometimes the crops are grown in mixture; sometimes they are grown separately and then mixed when the silo is being filled. The sorghums have been also used along with the legumes in much the same way as has corn. Another mixed crop occasionally used for silage, but with only fair success, is oats and field peas in mixture.

CHAPTER XII

SOILING CROPS

Soiling crops make excellent feeds for supplementing pasture in summer. With the aid of soiling crops the area of pasture needed for the dairy herd can be reduced, or more animals can be kept, and the cost of milk production consequently lowered. The other advantages of soiling crops are similar to those resulting from the feeding of silage during summer, with the addition of variety.

A very wide variety of crops can be used for soiling purposes, though the regions in which some of them can be used are quite limited. It is important, in outlining a soiling system, that only the feeds specially adapted for growth in the locality under consideration be selected, as otherwise certain failure will result. Care should be taken to include in the system as large a number of legumes as possible.

LEGUMINOUS

The leguminous crops suited for soiling are adapted to a fairly wide range of territory and, though they are not noted for phenomenal yields, they are especially valuable for the protein which they provide. The use of leguminous soiling crops tends to reduce the amount of protein concentrates needed in summer, and though in some cases not quite palatable at first, they are generally to be recommended.

Alfalfa.—This is undoubtedly the most valuable soiling crop among the legumes, since the various cuttings may all be

utilized as soiling. Alfalfa may be said to owe its importance as a summer forage crop to its high nutritive value, being especially rich in ash and protein; to its palatability; to its large total yield where successfully grown; to its drought resistance and to its long life and consequent small cost of seeding.

Alfalfa may be used to furnish green feed during the entire season if a sufficient acreage be available, as the various cuttings may be so timed as to keep the supply of succulent forage continuous. The period through which any one cutting is suitable is limited, however, as too early cutting decreases the yield, while delayed cutting will result not only in highly fibrous material but also in a decrease in the yield of the succeeding crop. Consequently, in herds of small or medium size, it is not possible to utilize large areas of alfalfa for soiling.

Generally the first cutting of alfalfa is very useful in the early part of the soiling season when other succulent feeds are not readily available. The later cuttings can also be used to advantage. The yields secured vary from 10 to 20 tons per acre. Green alfalfa stimulates milk secretion to a considerable degree, but the main drawback to its use is that, though it is fairly palatable, cows will not consume as much of it as they will of some other soilages. This is due, to a considerable extent, to the fact that most of the alfalfa used for soiling is fed during the early part of summer when pastures are still quite good.

Clovers.—The clovers are extensively grown in the United States, but in spite of this fact they are not as valuable for soilage as alfalfa. While red clover is more widely grown in the United States than any other legume, it does not fill an important place in soiling systems. It does not compare favorably with alfalfa in yield, although from 8 to 12 tons of green feed per acre are usually secured. It can be fed for only

a very short period as the stems quickly become woody. For soiling purposes it should be cut just before the blossoms appear, as at this period it yields more protein and less fiber per acre than at any other time.

Bloating seldom results from the use of red clover as a soilage, although it is advisable that the green feed be neither wet nor badly wilted when used. One disadvantage of red clover as a soiling crop is that when grown alone it frequently lodges. The second crop can be used for soiling, though better adapted for hay, pasture or seed production.

Mammoth red clover is larger and coarser than red clover and, though it gives heavier yields, is not quite so suitable for soiling. It is also less palatable. Alsike clover is adapted primarily to low, wet land, and though it tends to lodge and does not give quite as large yields as red clover, it is an excellent soiling crop. It produces a fine leafy forage, and since it is very palatable, cows will consume large quantities of it; it also stimulates milk production to a considerable degree. Crimson clover, though grown to a considerable extent in the south, is not a first-class soiling crop.

Sweet Clover.—The value of this plant for soiling purposes is in dispute, many reporting that it is not entirely satisfactory while others have lavished praise upon it. Yields may vary from 8 to 15 tons per acre, but the stems rapidly become woody and the feeding period is relatively short. It tends to be unpalatable to animals when fed in the green state, but they usually become accustomed to it and consume it with apparent relish, especially if the feeding of it is started early, before the bitter principle, cumarin, has developed to any considerable extent. The annual variety is perhaps of less value than the biennial.

Peas.—The Canadian field pea is an annual legume not very suitable as a soiling crop when grown alone. The yields are usually less than 7 tons per acre, and as the stems are

slender the crop tends to lodge. The Canadian field pea is useful in mixtures. In the case of the flat pea it is frequently difficult to secure a stand, and as the green forage is unpalatable it is not used for soiling purposes to any considerable extent.

Vetches.—Two vetches, the common and the hairy, have been used for soiling purposes, but the common vetch is not very palatable and cannot be recommended. The hairy, or winter, vetch is a very slender-stemmed winter annual, and though it yields from 10 to 12 tons of green feed per acre it tends to lodge and is very difficult to handle. It is fairly palatable, remarkably free from disease and insect pests and resists low temperatures and droughts, but the high price of seed frequently prevents its use for soiling purposes. Though trouble may be experienced in obtaining a stand where the crop has not been grown before, yet it will give satisfactory results under difficult conditions and thrives well on sandy soils.

Cowpeas.—Cowpeas are best suited to the southern states and are matured successfully in the northern sections only when the small early varieties are grown, and then the yield is small. While it is a larger-stemmed plant than the Canadian field pea, it is not self-supporting when the crop is heavy, and is therefore best suited for mixtures. Cowpeas furnish palatable forage during the latter part of the soiling season. Average yields of 6 to 10 tons per acre may be expected.

Soybeans.—This crop is well adapted to a wide range of conditions. In feeding value, green soybean forage compares well with green alfalfa, and the plant is more resistant to heat and drought. Where clover kills out, soybeans may be used as a catch crop, although, where the ground is poor good cultivation is necessary to keep down the weeds. Soybeans, which are becoming more widely used annually, mature for soiling during the latter part of the summer and will ordinarily yield 5 to 7 tons of green feed per acre. For

the best quality of soiling the seeding should be heavy, $1\frac{1}{2}$ bushels per acre being recommended.

NON-LEGUMINOUS

Corn.—Corn, being the main crop in a very large section of the United States, must be recognized as a possible soilage. Dent corn is used as soiling to some extent, returns rather a large yield and is quite palatable. It is difficult to handle and feed, however, and is not cleaned up well by the cows. Green corn cannot be safely fed until rather late in the summer, as it tends to cause digestive troubles, but during the later part of the season it may be fed until ready to cut for silage. It should be borne in mind that feeding green corn does not give the cow very much of a variety as compared to the winter ration, if this includes corn silage. Flint corn is adapted primarily to the northern part of the corn belt. It does not return as large a yield as dent corn though it is equally palatable.

Sweet Corn.—Sweet corn is the most palatable of the corns, and is used for soiling to a greater extent than the other varieties. In yield it ranks close to dent corn, and it is more satisfactory, as it stays green longer and the leaves do not fall so readily. Neither does it become so coarse nor is it so difficult to feed as is dent corn. It furnishes very good soilage when the ears have been removed previous to feeding, a practice followed near canning factories. The length of the feeding period will depend upon the number of varieties grown and may extend throughout a considerable part of the late summer. The use of green sweet-corn stover can be highly recommended for soiling wherever the crop is grown to supply canning factories.

Lesser Cereals.—The lesser cereals are grown over a very wide range of territory and are used to some extent for soiling. They are not of great importance for this purpose except when

grown in mixture with some legume. Oats do not make a very successful crop when grown alone, although they are highly recommended for mixtures. The yield secured will average about 7 tons per acre, and if cut early it makes quite a palatable feed. The main drawback to its use is that it ripens rapidly and so has not a long period of usefulness Barley is very similar to oats as a soiling crop and cannot be recommended except in mixture, especially as it tends to ripen even earlier than oats.

Winter wheat has been used to a considerable extent as an early crop in spite of the fact that it seldom yields over 8 tons of green feed per acre. It matures early, however, and where only limited pasture is available its use may be necessitated by the lack of other early green feeds. Winter rye has been used for soiling more than any other of the lesser cereals. It gives fair yields, averaging perhaps slightly more than wheat; it is only fair in palatability but can be used very early in the season for soilage purposes. It is, however, perhaps more valuable for early pasture than for soilage. Under some conditions green rye forage has been known to impart a peculiar and disagreeable flavor to milk.

Millets.—The millets, though perhaps not of primary importance for soiling purposes, have been used fairly extensively. The foxtail millets include common, German, Hungarian and many other varieties. These varieties have been used successfully for soiling, their main value being due to the fact that they mature late in the fall when the number of other crops available is limited. They can be used until the time of frost. Yields vary considerably, but 10 to 14 tons of green millet forage per acre is not uncommon. The foxtail millets vary considerably in value for soiling purposes. The common millet is fine-stemmed and leafy, giving a good quality of forage, while German millet is coarse and relatively unpalatable to stock.

Millet matures rather rapidly, and under the most favorable conditions is ready for harvesting forty to fifty days after seeding. To secure a good quality of forage, liberal seeding is advisable, 2 to 4 pecks per acre being generally recommended.

Japanese Barnyard millet, or Billion Dollar grass, is coarser than any of the foxtail millets. When cut before the plant heads out, it is fairly palatable, but as the crop matures it becomes woody and unpalatable. Thick seeding should be practiced to insure a fine-stemmed, palatable forage. Pearl millet, or cat-tail millet, is low in feeding value and cannot be recommended for use as a soiling crop.

Sudan Grass.—This crop is more especially suited to the arid and semi-arid regions, although it is being grown to some extent under quite different conditions and with fair success. It gives rather large yields of feed but dries out very rapidly and is apt to become fibrous and unpalatable when mature, a fact which minimizes its possible value as a soiling crop. Under some conditions it may be used successfully, but generally other crops will be more profitable for soiling purposes.

Amber Cane.—Amber cane is one of the most valuable crops for soiling purposes. The yield is large, and under average conditions 10 to 16 tons of green feed per acre can be obtained. On the Iowa State College Dairy Farm the average yield over a period of seven years was 12 tons per acre—the highest yield for any soiling crop used on the farm. The average cost of production was also lower than that of any other crop used for soiling purposes.

In addition to yielding heavily at low cost it is extremely palatable, and cows will consume large quantities of it—70 pounds per cow per day being generally a fair allowance. To insure a fine-stemmed forage, seeding should be at the rate of at least 70 pounds per acre, while 90 pounds will give even

better results. The crop is sometimes difficult to handle, but by the use of a small grain binder this trouble can be largely avoided.

Other Sorghums.—A few other sorghums, such as orange cane, kafir corn, feterita and milo, are occasionally used for soiling, but they are best adapted for arid conditions and cannot be generally recommended.

It has been proved that many of the sorghums, including Sudan grass, may at times be poisonous. The poisonous effects are generally produced in the second crop but may occur in the first. Poisoning does not occur unless the crop has been stunted by frost, drought or other causes. The poisonous principle is prussic acid, which is produced very soon after the crop is stunted. Sorghum silage that has been in the silo for a week or two and dry sorghum fodder do not produce poisoning as the prussic acid that may have been in them if they were stunted has been destroyed.

Sorghum poisoning has perhaps received too much publicity as out of ten thousand men raising Sudan grass pasture in Kansas in 1919 only three reported the loss of a few animals from this cause. No cases of poisoning have ever been reported after the animals had finished their first day on a Sudan grass pasture. The risks of poisoning are evidently obviated if the animals have become accustomed to the sorghum forage before it is damaged. This has been shown at the Iowa Agricultural Experiment Station by continuing to use amber cane for a soiling crop for some time after it was frosted and by the fact that cows were successfully kept on a Sudan grass pasture at the Kansas Experiment Station for some time after the forage was frosted.

Grasses.—Such crops as timothy, red-top, either alone or in mixture, brome and orchard grass, are occasionally used for soiling purposes, but they cannot be generally recommended, as they do not give large enough yields to be profitable, are

unpalatable, and contain very little protein, though the presence of clover in a mixed grass crop will add to its value. They can be more profitably used for pasture or hay.

Rape.—Though rape is used for soiling, it is not adapted to this purpose, the yields obtained are low, it may cause bloat and, in addition, it imparts a disagreeable flavor to milk at times.

MIXED

Mixtures of leguminous and non-leguminous forage crops have been widely grown for soiling purposes. Many of these mixtures have much to recommend them, since they possess several of the valuable characteristics of each of the other two groups. Their value depends upon the suitability of the individual crops for the locality in which they are grown and upon their adaptability for growth in mixtures. The mixed crops studied here will be grouped according to the legumes they contain.

Pea Mixtures.—Though they are not very successful when grown alone, Canadian field peas are valuable when grown in a mixture for soilage purposes. A mixture of oats and Canadian field peas is one of the most valuable of early soiling crops. Both are well adapted to a wide range of territory, and when grown together they give moderately large yields of very palatable feed. Yields of from 5 to 10 tons of green feed per acre have been secured quite frequently.

This crop is of great service in the early part of the season. The later sowings are not so satisfactory, as the oats ripen too rapidly and give an unpalatable feed. Best results are obtained if the feed is cut when the oats are in the milk and the peas have just filled the pods. Owing to the fact that oats mature more rapidly than do peas it is good practice to drill the peas about a week before the oats are sown. A satisfactory stand can be obtained by seeding $1\frac{1}{2}$ bushels each of oats and peas. The amount of soiling consumed at the time

oats and peas are available is usually not large, as pasture is fairly plentiful at that time, but in spite of this cows will consume from 40 to 60 pounds of the green feed daily. Canadian field peas give less satisfactory results when grown in mixture with barley than they do with oats. This is due to the fact that barley ripens more rapidly than oats.

Vetch Mixtures.—The vetch is more suitable in mixture than when grown alone, as its stems are not self-supporting. Oats and vetch have at times been recommended in place of oats and Canadian field peas, but the yields are generally smaller and the high price of vetch seed generally prohibits its use.

Winter rye and hairy vetch have given good results in mixture for soiling. The vetch increases the yield, protein content and palatability of the forage. This mixture will provide green feed earlier in the spring than will any other soiling crop containing a legume, and where no pasture is available its use may be advisable where the cost of seeding is not prohibitive.

Cowpea Mixtures.—Cowpeas have to some extent been grown in mixture for soiling purposes, especially in the south, where good yields have been obtained. On the whole, however, cowpeas cannot be generally advocated for growth with such crops as corn and amber cane. The cowpeas do add to the protein content of the feed, but where the other crop is sown thickly, a practice which must be followed for success with soiling, the cowpeas are smothered. Thus the extra seeding costs do not result in any appreciable increase in yield.

Soybean Mixtures.—Soybeans have been grown in mixtures very similar to those used with cowpeas and they do rather better. On the whole, however, they cannot be recommended in mixture as they give results not far different from those of the cowpeas.

CHAPTER XIII

MISCELLANEOUS SUCCULENT ROUGHAGES

THOUGH silage and soiling crops play an important role in inducing economical milk production, other succulent forages remain to be considered. The majority of these are of but little importance, but one, pasture, is deserving of considerably more attention than it generally receives.

PASTURE

Good succulent pasture is the feed, par excellence, for the dairy cow. The forage it provides is not only bulky, succulent and palatable, but it contains the nutrients required by the dairy cow in about the correct proportions. As a general rule, it may be said that no matter what the conditions are some pasture should always be provided for the dairy herd as the change from barn feeding is very beneficial as far as milk production is concerned, and the exercise the cows receive when at pasture keeps them in good working condition. When the cows are turned to pasture in spring the milk flow is maintained at a higher level than it would otherwise be, but the benefits of the pasturing season are also noticeable during the remainder of the lactation period.

The pasture season varies considerably in length in various sections, and the pastures themselves also vary greatly in quality, but it may be safely said that in the early part of the pasture season no additional roughage will be needed. It is well also to cut down, and in most cases entirely eliminate,

the grain ration during the early part of the season, except in the case of the heaviest producers. This cools and rests the digestive tract and puts the cow in better shape to handle concentrates when it again becomes necessary to feed them.

In most sections of the country, if pasture is used throughout the summer without some supplementary succulence, such as silage or soiling during the later and drier part of the season, from $1\frac{1}{2}$ to $2\frac{1}{2}$ acres of pasture per cow will be required. Even this will not give the best results, however, and it is generally better to feed some additional succulence. In this way the area required to maintain a cow will be reduced and the cost of milk production will be favorably altered. In some cases the pasture is entirely eliminated, but this is not generally advisable, as the use of even a limited area of pasture has an ultimate beneficial effect on the health and production of the herd which cannot be obtained in any other way.

The carrying capacity of, and the returns from, a pasture are greatly influenced by the method in which it is handled. It should be well drained and regularly manured. The practice of feeding grain during the latter part of the pasturing season helps to keep up the fertility of the pastures. The stock should not be turned on to it in spring until the land is well dried and growth has obtained a good start. Stocking the pasture before there is a good cover lessens the vitality of the forage, and trampling on wet ground does much damage. Overstocking at any time is also inadvisable. Weeds detract from the value of a pasture and should be kept down.

A great variety of pastures are in use, the commonest being blue grass. A good blue-grass pasture is excellent in spring and provides a considerable amount of good green forage in fall, but generally blue-grass pastures dry out badly during the summer and at that time are not very suitable for milk cows. In addition to blue grass, other grasses, such as Sudan

Fig. IX.—A Good, Well Shaded Pasture is One of the Greatest Assets of a Dairy Farm.

grass, are used as pure pasture crops. Such usage is generally quite definitely limited to certain sections and is of little general importance, though frequently of great value in certain localities. Legume crops, such as clover and alfalfa, are also used in the same way. There are disadvantages in the use of leguminous pastures. Bloat frequently occurs on such pastures, considerable amounts of feed are generally wasted, and frequently the growing of the crop for hay is the more profitable proposition.

The necessity of improvement in the type of pastures used for dairy cattle is quite general, and one broad recommendation will cover practically all conditions except in the drier sections. The best pasture for dairy cattle is one consisting of mixed grasses and legumes, as a mixture of grasses will provide palatable forage over a longer season than will any one of its individual constituents. The addition of clovers increases the protein content of the feed, and the greater variety enhances the palatability of the forage.

Good, well-tended pastures containing a variety of grasses and legumes are one of the greatest assets of the dairy farm, but it should be remembered that during hot, dry weather they must be supplemented with other succulent forage.

ROOT CROPS

Root crops are not much in evidence for the feeding of dairy cattle in any part of the United States, though they are widely used in the cattle-feeding and dairying sections of Great Britain and continental Europe and there is no doubt as to their value for feeding purposes.

Roots, such as sugar beets, mangels, turnips and rutabagas, are highly nutritious and very palatable. They have a beneficial laxative effect on the digestion and general health of the animals and stimulate milk production. Roots are characterized by their high water content, 75 to 90 per cent, and the

small amount of fiber, fat and protein which they contain. A considerable amount of the nitrogen present is not in the form of protein and so is of doubtful feeding value. The nutritive ratio of roots is rather narrower than that of silage. The various roots, excepting sugar beets, are of very similar value for feeding purposes. Sugar beets, owing to their high sugar content, have a greater feeding value than do the other root crops.

The dry matter of root crops is a little more valuable than that of silage, as a rule. Some state that it is equal in value to that of grain, and that roots may even replace half the grain ordinarily fed in a ration composed of grain, mixed hay and silage. This is overstating the value of the roots.

Roots are not used more extensively because of the labor involved and the difficulty of raising them and the consequent high cost of their production. Corn used as silage produces considerably more dry matter per acre than do root crops, and in addition the silage has the advantage of economy of production.

Where roots can be produced cheaply, they may play a very important part in the dairy ration. They are especially valuable as appetizers, due to their succulent palatable nature, for feeding exhibition or show stock, and for cows that are being given a heavy ration with a view to stimulating maximum milk production. They are used to a considerable extent with cows being forced for records and may be fed alone or with silage. Where they are fed alone, 50 to 100 pounds per day may be allowed.

BEET PULP

Beet pulp is the residue obtained in the manufacture of beet sugar. The wet pulp, 2 tons of which are equivalent in feeding value to 1 ton of silage, is sometimes used for feeding purposes near the sugar factories, but owing to its high water

content and consequent danger of spoiling and difficulty of transportation it is seldom used far from the point of production.

Beet pulp is usually obtained in the dried form and is a very excellent feed. It is classed by some as a concentrate, but better classed as a roughage, as it is usually fed as part of the roughage ration.

The dried beet pulp is sometimes mixed with the grain ration and it is an excellent material for rendering the concentrates bulky, though it has disadvantages for this purpose, as it has a great affinity for water and may abstract moisture from the other contents of the digestive tract and then swell to an extent that may induce digestive troubles. It is usually soaked and fed as a succulence; this is the preferable method of feeding it. It should be soaked for ten to fourteen hours before feeding, and in this time it will take up about three times its weight of water. It can be used in this form, partially or entirely, to replace silage or roots. When fed as the sole succulence, from 4 to 8 pounds of the dried material per day can be given, and when fed with silage, 2 to 4 pounds will, as a rule, be sufficient. It has a cooling effect, aids in keeping the digestive tract in good condition, requires but little room for storage and is a very excellent succulence to use, especially where silage or roots are not available in quantities large enough for general herd feeding. It is a useful feed for stimulating production, and owing to its transportability is specially valuable on the show circuit.

POTATOES

Potatoes are not much used for dairy-cattle feeding, but small unsalable ones can be utilized economically for this purpose. They can take the place of silage or roots, but not more than 20 pounds per head per day should be used. They are valuable mainly on account of the carbohydrates present.

The dry matter in them is probably of slightly lower nutritive value than that in silage. There is a slight danger of cows choking when fed potatoes, and too large quantities will result in a salvy butter of poor flavor.

PUMPKINS

Pumpkins, when available, can be used satisfactorily for milk production, $2\frac{1}{2}$ pounds of pumpkins being about equal to 1 pound of corn silage. It is sometimes said that pumpkin seeds tend to check milk production, but this statement is erroneous.

CHAPTER XIV

DRY ROUGHAGES

The dairy cow is preëminently a consumer of rough feeds, and as large a proportion of her ration as possible should be made up of roughages. In this way the best returns can be obtained from feeds that would not otherwise have a high market value. The roughages used in the feeding of dairy cattle should, as a rule, be grown on the farm. There is no more economical way of marketing the home-grown hays and other roughages than by way of the dairy cow, provided that those grown are suitable for dairy cattle.

The dry roughages supply a large amount of the bulky and fibrous part of the ration for dairy cows. This bulky material is necessary for the development of the digestive tract of young animals, and in the case of older animals it is essential for the most efficient digestion of the concentrated part of the ration. In addition, better returns can usually be obtained by feeding these roughages to the dairy cow than could be obtained by disposing of them in any other way.

LEGUMINOUS

Leguminous dry roughages are especially valuable for milk-producing cows, because of the fact that besides supplying bulk in the ration they also are capable of providing a considerable amount of digestible protein and other nutrients, and their ash content is usually of a valuable type, as it is high in calcium and phosphorus. Wherever possible, a

leguminous hay should be included in the ration of the dairy cow.

Alfalfa Hay.—This is undoubtedly the best dry roughage for dairy cows. It has a high content of valuable nutrients, especially protein and ash; it has a good effect upon the digestive system and is palatable. These properties, in addition to its bulk, render it an excellent material for balancing the silage and corn part of the ration.

For best results the alfalfa hay should be harvested in good condition. One of the main points to remember in curing alfalfa is that the leaf waste should be kept as low as possible. The leaves are the most nutritious portion of the plant, and every care should be taken to cure the hay with a miminum of handling, as each time the hay is handled some of the leaves are lost.

The relative values of the different cuttings of alfalfa depend, to a certain extent, upon climatic conditions. The crops with the fine stems and large proportion of leaves are to be preferred. At the Utah Agricultural Experiment Station it was found that no marked difference in value, for milk production, between first, second and third crop alfalfa existed. It is true, however, that under western conditions a better quality of alfalfa hay can be harvested than is generally possible further east. In the middle-west and east, as a general rule, the first cutting of alfalfa tends to be coarser and less leafy than the later cuttings, and so is not of as high a value for the milk-producing cow.

Alfalfa makes the most satisfactory hay for dairy cows, excelling in palatability, and being high in protein and ash, especially calcium, which is required in large amounts for milk production. Compared to bran, alfalfa hay furnishes about 80 per cent as much digestible protein, three times as much fiber and 65 per cent as much net energy.

One of the important functions of alfalfa hay in the ration

is to supply protein, but the limitations to its use should be recognized. Because of its low energy value, it cannot entirely replace concentrates, though where it is used, the grain ration may be reduced or may be less nitrogenous in character than would otherwise be required. Cows of low producing power may have their production stimulated to the highest degree by alfalfa hay, silage and very little grain, but with good producers a liberal grain allowance is also needed.

The allowance of alfalfa hay for milk cows should be about 1 to $1\frac{1}{2}$ pounds of hay per hundred pounds live weight daily. With heavy producing cows it is sometimes found advisable to cut some of the hay into $\frac{1}{4}$-inch lengths, moisten, and mix with the grain before feeding. This allows of the fullest utilization of the grain allowance, and the concentrates may also be somewhat reduced under such circumstances.

In the west, large numbers of cattle are reared without ever receiving any dry roughage but alfalfa hay. In spite of this, however, it must be stated that, in the majority of sections in this country, alfalfa hay is not the most satisfactory hay for young calves, as its high content of protein and ash tends to produce digestive and urinary disturbances.

Alfalfa meal, like alfalfa hay, is a roughage and not a concentrate and cannot replace the grain ration. Some alfalfa meal is good, but in other cases poor quality hay is ground up and sometimes mixed with molasses and sold under trade names. If good alfalfa hay is obtainable, alfalfa meal should not be used; ordinarily the dairy farmer can produce roughage more economically than he can purchase it.

Clover Hays.—The hays from the various clovers are worthy of great consideration for the feeding of dairy cows. As a whole they may be ranked as of about 80 per cent the value of alfalfa hay, from the standpoint of digestible protein content, though they are higher than alfalfa in net energy value.

Red-clover hay is a valuable feed for milk-producing cows and under conditions of cheap protein concentrates its value compared to alfalfa hay is relatively increased. The feeding of red and other clover hays is very similar to that of alfalfa hay. Red-clover hay is more valuable for calves than is alfalfa. Mammoth red clover makes a rather poorer hay than does red clover, as it is coarser, larger-stemmed and not quite so palatable.

Alsike clover is a fine-stemmed, palatable hay that ranks second to alfalfa hay in feeding value It is eaten with less waste than other clover hays and is the best hay for young calves.

The hay from crimson clover is important in the south and is equal in feeding value to that from red clover. It should be cut by the time the flowers at the base of the most advanced heads have faded, otherwise the hairs on the heads and stems become hard and wiry and consequently are apt to form balls in the digestive tract and thus cause intestinal trouble.

Sweet-clover Hay.—Not much experimental work has been done so far on the feeding value of sweet clover, though some rank it close to alfalfa hay. Stock usually object to sweet clover at the start when it is in the fresh green state. This is due to the presence of the bitter principle, cumarin. In the curing of the hay this objectionable substance is perhaps destroyed to some extent, and the hay is consequently more palatable than is the green feed. It supplies more net energy and crude protein but less digestible true protein than does alfalfa hay. One of the main objections to the use of sweet clover hay for dairy cattle is that it tends to become coarse and many of the leaves are lost in curing.

Field-pea Hay.—Field-pea hay is approximately equal to alfalfa hay for feeding purposes. It is rather difficult to cure, and consequently field peas are grown mainly in mixture.

Cowpea Hay.—This hay is difficult to cure but is used to

a considerable extent in the south. It is thought to be about equal to alfalfa hay for feeding purposes.

Soybean Hay.—It is about equal in feeding value to alfalfa hay but it is difficult to cure. In the past it has been used mainly in the south, but the cultivation of the soybean for forage purposes is extending quite rapidly.

Leguminous Straws.—Where leguminous crops are threshed, as alfalfa or clover for seed, or soybeans for the grain to be used for stock-feeding or the manufacture of oil, there is left a straw which has some feeding value. The leguminous straws are much lower in feeding value than the corresponding hays, though much better than the cereal straws. Soybean straw for example, contains only 2.8 per cent of digestible crude protein and 43.5 per cent of total digestible nutrients, while the corresponding values for the hay are 11.7 per cent of digestible crude protein and 53.6 per cent of total digestible nutrients. The greatest loss is in the protein, as this is concentrated to a considerable degree in the seeds which are removed.

NON-LEGUMINOUS

The non-leguminous roughages available for the feeding of dairy cattle have, as a rule, little to recommend them. They are unpalatable and poor in protein and other digestible nutrients; and though they generally have a high ash content it is poor in calcium and phosphorus.

In addition, the non-leguminous roughages are usually harvested and cared for in a very haphazard way and consequently deteriorate rapidly. In spite of this, however, a very large amount of these feeds is used for the feeding of milk cows in many sections. Though they have little value when used as the sole roughage, yet some of them can at times be used to advantage when limited amounts are fed with more valuable roughages.

Corn Fodder.—Corn fodder, though not as valuable as corn silage, makes a fairly good carbonaceous roughage. Where it has to be fed, some nitrogenous hay should also be used. Where there is silage and also some fodder, it is often advisable to give the cows a little fodder in addition to their silage They will relish small quantities of it, and a good plan is to give the cows access to it when out for exercise in the lots.

Corn Stover.—Owing to the absence of the ears, corn stover is of considerably less value than the fodder, but it can be used in a manner similar to that recommended for the corn fodder.

Cereal Straws.—The cereal straws, being poor in protein, low in digestibility and unpalatable, are not suitable roughages for milk cows. Their feeding value is very low and they rank as follows: oat, barley, wheat, rye, in decreasing value.

Timothy Hay.—This roughage is too fibrous and poor in protein to make a good cow-feed. Its feeding value is about the same as that of oat straw, and it should not be fed to milking cows. Frequently it can be sold for as high a price as it takes to buy alfalfa. The feeding of timothy to dairy cows is far too common at present, and everything possible should be done to discourage this practice.

Sudan-grass Hay.—This recently introduced crop, which is especially adapted to the drier regions, is increasing in popularity in some sections. As far as protein supply is concerned, it is about equal to timothy hay, but it provides energy about one-third more efficiently than does timothy and is more palatable. It is not a satisfactory hay for milk cows. but should prove fairly valuable for dry cows or young stock.

The Sorghums.—Both the sweet, or saccharine sorghums, or sorghos, and the non-saccharine sorghums are valuable forage crops in the drier regions, especially in the southwest. If they are drilled in and intended for forage, they are cut before they are fully matured and shocked in the same man-

ner as corn. They then produce a valuable fodder. If grown for seed, they are allowed to mature before shocking, and the stover obtained after threshing is not valueless. Kafir fodder and stover are the most valuable dry roughages of the grain sorghum group and have about the same value as the corresponding corn products, while the forages produced from feterita are of somewhat lower value, and milo, kaoliang and shallu come at the bottom of the scale. Sometimes these crops are sown broadcast; this gives a thick crop of fine-stemmed forage which when cut with a mower gives a valuable hay.

Of the sweet sorghums, amber cane is the best known, as it can be grown over a wide range of territory, including all of the corn belt. It can be handled in the same way as corn fodder and, like all the other sorghum forages, it is not very high in protein and is best suited for the feeding of dry stock.

The Millets.—Of the large variety of millets, none is really valuable as dry roughage for dairy cattle as they are all low in protein. The foxtail millets, including the common, Hungarian and German types, are perhaps the best, and they are of some value in the drier regions of the northwest. They should be cut early for hay, before the hard seeds are formed. The Japanese Barnyard millet gives large yields of coarser feed, while the broom-corn millets give a low yield of very woody forage which is practically valueless for dairy cattle.

Buckwheat Straw.—The straw of buckwheat contains more digestible crude protein but less digestible carbohydrate equivalent than the cereal straws. It is of very low value and may cause digestive disturbances if fed in liberal amounts and therefore should not be offered to dairy cattle.

Flax Straw.—This is of low value, and the straw from green immature plants may contain enough prussic acid to be dangerous when fed to live stock. It should not be used with dairy cattle.

MIXED

Only a few mixed dry roughages belong to this group, but they are quite valuable, especially where alfalfa or clover hays are not available.

Mixed Hay.—Hay from mixed grasses is better than timothy hay, and if there are also some legumes present it makes a fairly satisfactory feed. Mixed hay, even with legumes present, is not as good as alfalfa or clover hay for milk production, and when it is used, rather more nitrogenous concentrates will have to be fed than would be necessary if a legume hay were provided. Mixed hay is good for young calves, especially if there are plenty of legumes present.

Oat and Pea Hay.—A mixture of oats and Canadian field peas, in equal parts and drilled in at the rate of 3 bushels per acre, will yield a good hay for dairy cows. The best results are obtained when the crop is cut just as the oats are entering the dough stage. Though not quite as good as alfalfa or clover hay it makes an excellent substitute, and is especially valuable where a crop of hay has to be obtained in the season in which the seeding is done.

CHAPTER XV

THE CEREAL GRAINS AND THEIR BY-PRODUCTS

The concentrates include a very large number of materials of varied characteristics. They can be grouped according to their general character, frequently according to their content of crude protein. It is perhaps better, however, to consider them on the basis of their plant source, cereals, legumes and oilseeds.

The cereal grains form one of the most important groups of feeding stuffs in the United States, and their scope is world-wide. They are generally considered as feeds used largely to provide energy, but many of their by-products are also valuable sources of protein. Most emphasis is generally put on corn, but in certain sections of the country other cereal grains are of more importance than corn.

CORN AND ITS BY-PRODUCTS

The corn crop of the United States exceeds, in acreage, yield of grain, and value, all the other cereals combined; it must therefore be relied on as the main grain for the feeding of animals in this country, especially throughout the corn belt.

Of the six races of maize grown, only three are of importance from the viewpoint of the feeder of dairy cattle. These are dent, flint and sweet corn. The dent and flint corns differ chiefly in the condition of the starch which they contain. Sweet corn contains more crude protein and fat and less carbohydrate than the other races. Before ripening, sweet corn

contains a large quantity of sugar, which is later changed to starch; and though this sugar is not more nutritious than starch it does increase the palatability of the corn.

Sometimes the question of a difference in feeding value between yellow and white corn arises. In general the chemical composition of white corn is practically the same as that of yellow corn, though there may possibly be a difference in the constituents of the proteins of yellow and white corns. Recent investigations also indicate that yellow corn perhaps contains sufficient of the vitamine, Fat-Soluble A, for normal growth and reproduction, while white corn contains none of it. If this proves to be correct, it will be of great significance where corn constitutes the major portion of the ration of animals and will again emphasize the necessity for variety in the ration. Where the ration is varied in character there are no practical differences in the feeding values of yellow and white corn, though popular opinion frequently attributes a slightly higher value to the yellow variety.

It has already been shown that the yellow color of butter fat is due to pigments, the carotinoids, derived from the feed, but yellow corn does not appear to give any more color to dairy products than does white corn. This is probably because the color of yellow corn is due to the presence of xanthophylls rather than of carotin.

The corn grain has a low protein content, and of the protein present about 58 per cent is zein and 30 per cent glutelin. Zein is an inefficient protein as it lacks tryptophane and lysine, but it has been found that the mixed proteins of corn are more efficient than those of oats or wheat. Corn is also deficient in mineral constituents, especially lime, and sometimes phosphates. These are limitations which must be borne in mind in the feeding of corn, and a variety of constituents from other plant sources should be fed with the corn to overcome these deficiencies.

The handling of soft corn is a problem that occasionally confronts the dairy farmer. The best solution is to put it in the silo, but where it is not possible to ensile the crop the grain should be fed as soon as possible. Drying outfits are now to be had, and good results have been obtained with some of them. Fairly satisfactory results can also be obtained in the preservation of soft corn through the use of salt. It is recommended that one-half to one pound of salt per hundred pounds of soft corn be used at cribbing time.

Soft corn has not as high a feeding value as an equal weight of well-matured corn, but when calculated on the dry-matter basis there is little difference between them, and there is no reason why soft corn cannot be utilized economically by the dairy cow if it is fed carefully and with the proper supplements. The main difficulty in its use is the problem of storage, as the high moisture content is favorable to mold growth.

Where corn is stored in large quantities, the shrinkage must be taken into consideration as it may amount to a considerable item. With good corn the shrinkage from November to April amounts to about 12 per cent, while during the months of November and December it is generally over 5 per cent. Good corn is generally figured on the basis of 14 per cent of moisture. Shelled corn does not keep as well in bulk as does ear corn, on account of the difficulty of maintaining proper ventilation for the removal of moisture.

Corn Preparations.—In the corn belt, corn is generally the most economical concentrate for providing energy that is available for the feeding of dairy cattle. On account of the limitations which have already been pointed out, corn should not, as a rule, be used as the sole concentrate for milk cows or other stock. This is especially important where the corn plant also provides part of the roughage used in the ration. There are several forms in which corn grain may be fed to dairy cattle, and these vary considerably in their efficiency.

Ear Corn.—The feeding of ear corn to dairy cows is much too common at the present time. About 20 per cent of ear corn is cob, which contains about 30 per cent of fiber and pentosans—carbohydrates of doubtful feeding value. No extensive work has as yet been done in comparing ear corn with other corn preparations as a feed for dairy cows, but experiments at the Iowa Agricultural Experiment Station indicate that ear corn is about 5 per cent less valuable for milk production than is cracked corn, when equal amounts of corn-grain dry-matter are fed; in other words, 100 pounds of ear corn, when fed to dairy cows, would induce the production of about 5 per cent less milk than would 80 pounds of cracked corn, or 105 pounds of ear corn are only equal to 80 pounds of cracked corn for milk-producing purposes.

Shelled Corn.—This corn preparation is quite widely used and is slightly better than ear corn, but not as efficient as cracked corn for milk-producing purposes.

Cracked Corn.—One of the best preparations of the corn grain for the feeding of dairy cattle is cracked corn, as the cracking renders it more palatable and probably allows rather more complete digestion. Where the grain ration contains plenty of bulky constituents, cracked corn should be used in preference to any of the other preparations, and under those conditions it is generally an economical source of energy either for the fattening of cows preparatory to freshening or for milk production.

Corn Meal.—There is no definite line of demarcation between corn meal and cracked corn. From work done at the Iowa Station, it appears that there is no advantage to be gained by extreme fineness of grinding. Fine corn meal and cracked corn have similar values for milk production, but the more finely ground material has disadvantages. It is a heavy feed which is more difficult to digest than the cracked corn, unless a greater proportion of bulky constituents be

included in the grain ration. There is, therefore, no advantage to be obtained from the expenditure of the extra power required to bring the feed into the fine state of division in which it exists in corn meal.

Corn-and-cob Meal.—In spite of the highly indigestible cob, corn-and-cob meal is an exceptionally valuable feed. Where there are no other bulky constituents in the grain ration, corn-and-cob meal is as valuable as cracked corn for milk-producing purposes; but where light, bulky constituents, such as ground oats and bran, are included in the grain ration, corn-and-cob meal is 20 per cent less valuable than cracked corn. This is due to the fact that the ground particles of indigestible cob are of no nutritive value and do not increase the efficiency of the ration when other bulky constituents are present, but when other light feeds are absent the particles of cob help to loosen up the grain mixture and so render the corn-and-cob meal of higher value—not through adding nutrients to the ration, but simply by their mechanical effect.

Corn By-products.—Though corn is one of the most useful of grains, it is valuable also for other reasons. In the manufacture of starch, glucose and alcohol from corn, several by-products are obtained which are at times valuable adjuncts to the dairy ration, especially as some of them contain a high percentage of protein. Quite frequently some of these protein feeds are easily available in the corn regions, but it should be remembered that it is not, as a rule, advisable to use them as the sole protein supplement where corn grain and corn silage form a large part of the ration, as their use does not make up for the deficiencies of the corn plant in the way of ash and certain constituents of the proteins.

Hominy Feed.—In the manufacture of hominy grits, which are used for human consumption, or of brewers' grits, the by-product known as hominy feed is obtained. It is also known as hominy meal or chop, and is a mixture of the bran

coating, the germ and a part of the starchy portion of the corn kernel. It contains much more fat, slightly more fiber and less nitrogen-free extract than does corn. Like corn, it has a low content of protein. As it is light and bulky it is in some ways preferable to corn meal but it is less palatable. Hominy feed is less digestible than corn meal, but it keeps well and is remarkably free from adulteration. It is about equal to corn in feeding value and frequently forms an economical source of carbohydrates.

Germ-oil Meal.—In the manufacture of starch from corn, the germs are removed and dried and most of the oil expressed. The resulting material is sold as corn oil-cake or ground and sold as corn oil-cake meal, germ-oil meal or corn-germ meal. This feed contains less protein and more fat than does gluten feed and has a fairly good ash content. Its feeding value is fairly well indicated by its composition. However, it is not a very satisfactory concentrate for dairy cattle, as it is unpalatable, and owing to its high fat content it tends to become rancid and so cannot be stored for any great length of time.

Corn Bran.—The corn bran is the outer layer removed from the kernel in the manufacture of starch or glucose. It contains less crude protein and ash and more fiber and total digestible nutrients than does wheat bran, and its protein is not very easily digested. It is usually an expensive feed, but little of it is now found on the market as it is generally mixed with other corn by-products. Where used as a protein supplement for milk cows, it is about equal in value to wheat bran.

Gluten Meal.—When the bran, the germ and the greater part of the starch have been removed from the corn grain in the manufacture of starch and glucose, there is left the gluten and a solution of ash and other materials known as corn solubles. All of the gluten was at one time dried and sold as gluten meal or corn-gluten meal, but now the corn solubles are generally added, as this improves the ash content

of the gluten. Gluten meal is a heavy feed, having a tendency to cause digestive troubles, and so should be used only in limited quantities and with suitable admixtures of bulky feeds.

Gluten Feed.—Gluten feed or corn-gluten feed is a mixture of gluten meal and corn bran and usually, though not always, contains the corn solubles. It is a feed high in protein, but it is much safer to feed than is gluten meal as the corn bran renders it comparatively light and bulky. Gluten feed is the best-known and most widely used of the corn by-products but, though it frequently is an economical source of protein it should not be used as the sole supplement to corn.

Corn-distillers' Grains.—This is the residue obtained in the manufacture of alcohol and distilled liquors from corn. This residue contains the crude protein, fiber, fat and more insoluble portions of the grain. A small part of this material is used as distillers' wet grains, but owing to the large amount of moisture it contains, with the consequent expense of transportation and tendency to fermentation, it is used in this form only near the point of production. It is a useful feed if properly handled, but if care is not taken it will ferment and may then cause digestive troubles. This fermenting material when left in the barns will also impart disagreeable odors to the milk.

When dried, the residue is sold as distillers' dried grains and is a valuable concentrate. It contains about twice as much crude protein and three times as much fat as wheat bran and has a feeding value superior to that of gluten feed. It is palatable and its bulky nature renders it specially valuable.

OATS AND THEIR BY-PRODUCTS

The oat crop is grown over a wider area in the United States than any other grain. Though used to a considerable extent for human consumption its importance as a source of feed for

dairy cattle is obvious, though its by-products are of little importance.

Oats.—The oat grain is used to a considerable extent in the human dietary, but very large amounts of it are available for the feeding of dairy cattle. Oats are higher in crude protein, fiber and ash than corn, and almost equal to it in fat content. There are no better grains than oats for milk-producing cows, and practically the only limit which needs to be put on their use is that due to economy. Though their use for general herd feeding is often limited by their price, it will usually be found advisable to include oats in the ration of high producing cows, and those that are well along in pregnancy or in poor condition. Oats are very palatable, especially when ground, and the grinding increases their bulk to a marked degree. The use of oats in the feeding of calves is also to be recommended, but with young calves the whole grain is preferred.

Oat By-products.—There are several by-products, including oat hulls, and oat shorts or middlings, made in the manufacture of oatmeal, but they are of little moment in the feeding of dairy cattle, except that they are frequently used as constituents of mixed feeds. Almost one-third of oat hulls consists of crude fiber, and they have little feeding value. They are usually incorporated with other feeds and their bulk may then have some beneficial effect. Oat middlings contain more fat than does wheat bran and, like oat bran, oat dust and oat clippings, they are usually put into compound feeds.

WHEAT AND ITS BY-PRODUCTS

Wheat is the chief American cereal used for human consumption, and its consequent high price precludes the use of much of it for cattle feeding, though its by-products are of considerable importance. There are several varieties, such as durum and macaroni wheats and emmer, which do not need separate consideration.

Wheat.—Only the poor or spoiled samples of wheat are available for stock feeding, but this damaged grain differs little in composition from the marketable product, though it usually contains a slightly larger amount of moisture and protein. Though wheat contains a little more protein than does corn, it is essentially a carbohydrate feed and is slightly lower than corn in feeding value. Wheat should always be ground before feeding and should never be fed alone; the presence of the proteins, gliadin and glutenin, and the absence of any marked amount of oil or fat, cause the formation, in the alimentary tract, of pasty masses of the same consistency as dough, and these may cause digestive disturbances.

Wheat Bran.—The coarse outer coatings of the wheat grain, removed in the milling process, are the bran. The protein content of this feed is high and it has a fair amount of other digestible nutrients, though it has a relatively high content of crude fiber. The ash content is also high and is rich in phosphates, though poor in lime. Bran is a light, bulky feed, is extremely palatable and has a beneficial laxative and cooling effect on the digestive system. Its laxative action is due to the presence of phytin, an organic compound containing phosphorus, magnesium and potassium. Wheat bran has a feeding value about equal to that of oats. Owing to its high price, bran is sometimes not a very economical supplement for corn and other carbonaceous feeds. It can seldom be profitably fed to all the animals in a herd, but even when it is high-priced it is usually advisable to feed it to cows just before and after freshening, to animals that are being forced for records, and to young stock. Its laxative properties and its palatability render it extremely useful, in the form of mashes, for cows that are off feed or otherwise out of condition.

Wheat Middlings.—Shorts, standard middlings, or wheat middlings, are the fine particles of the outer and inner bran separated from the bran and white middlings. Though they

have a higher protein content than wheat bran they should seldom be fed to dairy cows, as they are unpalatable, and more economical sources of protein can usually be obtained. When fed they should be used only in small quantities and mixed with other feeds.

Flour-wheat Middlings.—Flour or white middlings are that part of the wheat offal intermediate between shorts and red dog flour. This feed contains less crude fiber and more protein than do the standard wheat middlings. Like shorts, they should be fed but rarely and then only in limited quantities.

Red Dog Flour.—This is a low-grade flour containing the fine particles of bran. It contains less fiber and ash and more nitrogen-free extract than does wheat bran, and in feeding value it is very similar to good white middlings.

BARLEY AND ITS BY-PRODUCTS

In the past the use of barley for feeding purposes has been restricted largely to the Pacific-coast region in this country, but its use in the feeding of dairy cattle has recently shown a fair degree of expansion. Some of the by-products, however, have been more widely used.

Barley.—Though containing more protein than does corn, barley is strictly a carbohydrate feed. Many feeders are prejudiced against the use of barley for milk-producing cows on the ground that it tends to cause the cows to dry up. This prejudice is unfounded; cows have been fed with barley as the sole grain throughout the lactation period without any deleterious effects. In the past, only damaged barley has been available for feeding purposes in certain sections, but this discolored grain is quite as fit for feeding purposes as the brighter samples. Where it can be purchased economically, barley will be found to be a good energy-providing feed. It is a palatable feed and has a nutritive value just about the same as that of wheat and about midway between that of

corn and oats. It is generally fed ground, cracked or rolled, but the rolled grain is to be preferred as the ground barley forms pasty, indigestible masses in the alimentary canal.

Barley Bran and Barley Shorts.—These feeds contain less protein than do the corresponding wheat products and are of very little importance in dairy-cattle feeding.

Malt-sprouts.—The sprouts separated from malted barley are dried and sold as malt-sprouts. Their content of carbohydrates and fats is low, and they contain a large amount of digestible crude protein, though about one-third of it is amides and of little feeding value. They are a light, bulky feed, but owing to the presence of betaine and choline they are unpalatable, though stock may acquire a liking for them. They are of lower feeding value than brewers' dried grains. The feeding of over 2 pounds per day cannot be advised and their use is open to criticism. Malt-sprouts have a great affinity for water, and as they swell greatly when moistened they should be soaked for several hours before feeding, as this will prevent digestive disturbances. Where only small quantities are fed, soaking may not be necessary, but in this case the malt-sprouts should be mixed with other feeds as they are extremely dusty.

Brewers' Grains.—This is the residue of the malted grain, obtained in the manufacture of beer and non-alcoholic beer substitutes. The brewers' wet grains, like distillers' wet grains, are in common use for feeding purposes only near the point of production. When properly handled they make a profitable feed, the usual daily allowance being 20 to 30 pounds per cow. It is very essential that they be fed before decomposition starts; otherwise digestive disturbances are sure to result, and the odors from the decomposing feed will also be imparted to the milk. They differ from the barley grain chiefly in the water-and-carbohydrate content and they are worth about one-fourth as much as the dried grains. Brewers'

dried grains are a palatable and bulky feed and at times have been an economical source of protein. They have a rather higher value for milk production than has wheat bran.

RYE AND ITS BY-PRODUCTS

Rye does not differ materially from barley in composition or feeding value. It is preferably fed ground and mixed with a relatively large proportion of other feeds, as it is unpalatable to dairy cows and may impart a disagreeable bitter flavor to milk and butter. If fed alone or in large quantities, it may also cause digestive disturbances, and its importance in the dairy ration is not great.

The chief rye by-products are middlings, bran and distillers' grains. The rye middlings and bran do not differ much from the corresponding wheat by-products, except that they are somewhat lower in fiber, fat and protein and are unpalatable. Rye distillers' grains contain considerably less protein and fat than do those made from corn, and consequently are of less value in the feeding of dairy cattle.

RICE AND ITS BY-PRODUCTS

Damaged and low-grade rice, both rough and hulled, is sometimes fed to cattle and has a slightly higher feeding value than corn. Like corn, it is used as a source of energy. The amount available for feeding purposes is small. Rice hulls, the first layer removed from the grain in the preparation of rice for human consumption, should never be fed to cattle, for not only are they unpalatable, very fibrous and practically devoid of digestible nutrients, but they contain a large percentage of siliceous or sandy material which causes great irritation in the digestive tract and may even result in death.

The rice bran, the layer just within the hull, is removed in preparing rice. It is a fairly nutritious feed if it has not been adulterated with the hulls, but owing to the large amount of oil present it is not a very satisfactory feed, as the breaking down of the oil causes it to develop rancidity rapidly in storage. Rancid rice bran is unpalatable and may taint the milk, but it is said that the rancidity can be prevented by kiln-drying the bran.

Rice polish, removed from the grain after the hulls and bran have been separated, is equal to corn in feeding value, but the demand for it in the arts removes most of it from the list of feeds available for dairy cattle.

THE SORGHUMS

The sorghums are drought-resisting plants, of importance in the arid and semi-arid regions only. They may be divided into the non-saccharine or grain sorghums, and the saccharine or sweet sorghums, or sorghos. The latter are used mainly for forage purposes, though in some cases the grains produced are used to a slight extent as concentrates.

The non-saccharine or grain sorghums include kafir, durra, milo, feterita, kaoliang and shallu. They are all very similar in composition and are essentially energy-providing feeds, carrying about the same amount of crude protein and nitrogen-free extract as corn. They are not quite so palatable as corn. The grain is usually ground, and in some cases the entire head is ground, the product then resembling corn-and-cob meal in composition.

Kafir grain is astringent and constipating in action, and so must be fed with laxative feeds and only in moderate amounts to milk-producing cows. Milo is superior to kafir, as it is more palatable and has a laxative effect on the digestive sys-

tem. Feterita and kaoliang are of less value than milo and kafir, while the others mentioned are of no great importance

THE MILLETS

The grain of the various millets is used but little in the feeding of dairy cattle, and is 20 to 25 per cent less valuable than corn. When used, it should be ground.

CHAPTER XVI

THE LEGUMES, THE OIL SEEDS AND THEIR BY-PRODUCTS

THE concentrates included in this grouping come from a wide variety of sources and are of importance largely on account of the liberal amounts of protein which they supply. The legumes provide the most useful and valuable dry roughages for dairy cattle and, in addition, some exceedingly valuable concentrates are obtained from them. The concentrates of leguminous origin have a high content of protein, and in some cases this has been accentuated by the extraction of the oil, which is generally present in liberal amounts. Of the non-leguminous oil seeds, only two, cottonseed and flaxseed, contribute large amounts of feed useful to the dairy farmer; the others, the coconut and palmnut, are not yet of great importance in America.

PEAS

The common field, or Canadian field, peas make a very good concentrate although they are not very widely used in the feeding of dairy cattle. They contain about twice as much digestible crude protein as the cereal grains and are also rich in phosphorus and potash. They are probably equal to gluten feed for milk production and should be fed cracked or ground In combination with corn they may form one-third to one-half of the grain ration.

COWPEAS

Owing to uneven ripening and the consequent difficulty in harvesting, cowpeas are used mainly as a forage crop. They are very similar to the field pea in composition and when fed should be cracked.

BEANS

Most of the beans grown in this country are used for human consumption, but there are many damaged and cull beans which can be used successfully for feeding dairy cattle, as they are rich in protein. They should be cracked before feeding or ground into a meal. The former method of preparation is the better, as the meal is a heavy feed. In the south, velvet beans have proved to be valuable for milk production, but they must be ground before feeding.

SOYBEANS

Of all the leguminous seeds used in cattle feeding, soybeans are the richest in crude protein and ash. They are a valuable crop in the south, although in the past they have largely been used as a forage crop. The soybean is adaptable to the same range of climate as corn, however, and the prospects for its expansion in the future are good.

Soybeans should be cracked before feeding. They are very palatable and are quite comparable to the other feeds of high protein content as far as their value for milk and butter-fat production is concerned, though too large an allowance of soybeans in the ration will cause the production of a soft butter.

Large areas of the United States, in which corn can be grown, successfully produce all the roughages needed for dairy cattle as well as plenty of energy-producing concentrates. They are, however, now dependent on outside sources

for concentrates of high protein content. But if the development of the soybean as a grain crop progresses as rapidly as it is doing at present, there appears to be a good opportunity for those sections to become absolutely independent as far as all dairy-cattle feeds are concerned.

The soybean, having a high oil content, is used in the manufacture of oil, and the resulting by-product is used for feeding purposes. For a number of years this soybean cake or meal was imported from the Orient and used on the Pacific coast with good results. Now, however, the extraction of soybean oil is a rapidly growing industry in the United States, and greater amounts of the soybean meal are yearly becoming available for cattle feeding. It appears to be of about the same value as oil meal for milk production, and as the oil has been extracted there is less risk of it producing a soft butter than there is where the unextracted beans are fed.

PEANUTS

Unextracted peanuts, though used in the feeding of hogs in the south, are not used for dairy cattle. Peanut meal, which is the ground residue left after the oil has been extracted, is used to some extent, however. When this meal is made from hulled peanuts it contains over 40 per cent of digestible crude protein and it seems to be of about the same value as oil meal for milk production. The meal from the unhulled nuts is called peanut feed and contains about 23 per cent of crude fiber and 20 per cent of digestible crude protein. Peanut products tend to produce a soft butter and are not very palatable to dairy cows, though they do become accustomed to them.

Peanut hulls are sometimes ground and used for adulterating feeding stuffs and are also fraudulently sold as "peanut bran." They contain over 50 per cent of crude fiber and are less valuable than straw for feeding purposes.

COTTONSEED AND ITS BY-PRODUCTS

At one time the seed of the cotton plant, after its separation from the lint, was allowed to go to waste or, at the best, used for fertilizer. Now, however, the millions of tons of cottonseed produced annually in the United States are used largely for feeding purposes.

It has been shown, by both practical and experimental work, that cottonseed is not always a safe feed. The seed itself, and also its products, may under certain conditions cause peculiar physiological disturbances which result in a staggering gait, sometimes blindness and even death. These effects are most easily produced in the case of young animals and consequently cottonseed products should never be fed to calves and other young stock.

The exact cause of this deleterious effect of cottonseed products has not yet been determined, though it has been attributed to many factors. It is generaly conceded that these effects are poisonous rather than the result of a nutritional insufficiency of the cottonseed. This toxicity has been ascribed to many factors at one time and another, but most of these factors have now been removed from the list of possible deleterious agents. None of these need be mentioned, with the exception of prussic acid. It has been at times held by some that the presence of prussic acid was the cause of cottonseed poisoning. Cottonseed products, like many other feeds, may at times, when in bad condition, contain enough prussic acid to cause poisoning, but as a general rule cottonseed shows no tendency to contain prussic acid, and the typical symptoms of cottonseed poisoning are not those of prussic-acid poisoning.

There remain at present two substances which are classed as the causes of typical cottonseed poisoning. These are gossypol, a pigment found in cottonseed, and a sulphur combination which occurs in the protein of cottonseed. Gossypol

is present to the extent of about .6 per cent in the raw cottonseed kernels, and, as it is soluble in oil, about three-fourths of it is removed when the oil is expressed by the cold-press method. The hot-press method of extraction reduces the amount of gossypol present in cottonseed products still further, as the heat has a destructive effect on it. The gossypol is supposed to have a general poisonous effect. It is also stated that the sulphur of the protein of the cottonseed abstracts iron from the blood, thus reducing its oxygen-carrying properties and ultimately resulting in the characteristic symptoms of cottonseed poisoning.

Which, if either, of these two substances is directly responsible for cottonseed poisoning, has never been definitely determined and no very successful antidote has been found, though it is stated that the administration of iron sulphate, or copperas, in the drinking water of stock will prevent, or at least delay, the onset of typical cottonseed poisoning. Those who attribute the toxicity to gossypol say that the iron of the copperas unites with the gossypol, thus rendering it harmless; while those believing in the sulphur of the protein as the dangerous element assume that the trouble is prevented through this sulphur combining with the additional iron in the digestive system and consequently being unable to abstract the iron from the hæmoglobin of the blood. No matter what the cause, it should be remembered that cottonseed products are not suitable feeds for calves but that they are satisfactory for dairy cows when fed with a suitable ration.

Cottonseed.—Very little whole cottonseed is now fed to dairy cattle as nearly all of it is used in the manufacture of oil. In certain sections of Europe, however, the whole cottonseed is sometimes ground and fed. This gives a very concentrated product, high in both protein and fat, and owing to its high content of oil it is difficult to store and handle. It is not a very satisfactory feed as it tends to produce digestive troubles.

Cottonseed Hulls.—The hulls removed from the cottonseed before the oil is extracted are high in fiber and exceptionally low in their content of digestible nutrients. In the south they are sometimes used to add bulk to the ration, but as a rule more valuable methods of rendering a ration bulky can be obtained. Cottonseed hulls are also sometimes used as a filler in cottonseed and other feeds, but they should not be bought for the feeding of dairy cattle.

Cottonseed Meal.—This is one of the richest and most nitrogenous feeds available and is often an economical source of protein. It is composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil, and legally must contain at least 36 per cent of crude protein. Cottonseed meal is sold according to grade; the three grades recognized are as follows: choice, containing at least 41 per cent; prime, containing at least 38.6 per cent; and good, containing at least 36 per cent of crude protein.

Besides being high in protein, cottonseed meal contains a relatively large amount of fat and ash, and these constituents also add to its value. It has a constipating action and therefore should be fed with some laxative feeds, such as linseed-oil meal and bran. Cottonseed meal should always be bought subject to guarantee, as it varies greatly in protein content. It should be in good fresh condition, as moldy meal, like other damaged feeds, is not only unpalatable, but may also be dangerous to stock. Under certain conditions any grade of cottonseed meal may prove poisonous; it should never be fed to young calves or to cows about to freshen, and the feeding of it to bulls is not good practice. However, there is no danger in feeding a limited amount, up to 2 pounds per day, to milking cows, provided it is mixed with laxative, bulky and less nitrogenous feeds. It is an excellent feed for cows when on pasture, as its constipating effect counteracts the action of washy grass, and, unlike oil meal, it tends to

harden the butter, which is oftentimes soft during summer, Where silage or roots are used it is an excellent feed in winter, but it should not be included in a ration containing no succulent feed.

Sometimes cottonseed meal contains excessive amounts of hulls, due either to incomplete separation before the meats are ground for the oil-extraction process or to intentional adulteration with hulls. The excess of hulls detracts from the value of the meal. The presence of large amounts of hulls can be detected by a very simple process. A teaspoonful of the meal is stirred up with about two ounces of boiling water until all the particles are wet and floating. The mixture is allowed to settle for five to ten seconds and the supernatant liquid is decanted. The liquid poured off is mustard colored, and the presence of a dark-brown sediment in large amounts indicates adulteration. This sediment is ground-up hulls and it can be washed once or twice to free it from the meal. This is only a comparative test, but an adulterated meal will give a much larger sediment than will a good sample.

Cottonseed Feed.—This is a mixture of the meal and hulls of the cottonseed and contains less than 36 per cent of protein. It is of less value than cottonseed meal, the content of hulls and protein being the factors which indicate its relative feeding value.

Cold-pressed Cottonseed Cake.—This is the product resulting when the oil is extracted from the undecorticated, or unhulled, cottonseed by the cold-pressure process and it includes the entire cottonseed less the oil extracted. This feed contains more fiber than does cottonseed meal, on account of a larger percentage of hulls, and it is consequently less valuable as a feed. It is usually sold as broken cake but sometimes it is ground into a meal. It is also put on the market under various trade names.

FLAXSEED AND ITS BY-PRODUCTS

Flaxseed and its by-products provide some feeds which are among the most widely used, and which are very valuable on account of their high protein content and their laxative properties. The laxative action is due to the presence of compounds which absorb water very readily and, becoming mucilaginous, lubricate the intestinal tract.

Cases have been reported where animals died from prussic-acid poisoning when fed oil meal and other flaxseed products. Flaxseed products contain cyanoglucosides and an enzyme which is capable, under certain conditions, of splitting off prussic acid from these glucosides. As a rule, however, this does not take place unless the feed has become moldy, has been heated, or in other ways caused to ferment. The bulk of this pernicious enzyme is destroyed by the heating in the manufacture of oil meal by either the old or new process and consequently there is little danger of poisoning from this feed unless it is moldy or otherwise spoiled. In the feeding of unextracted flaxseed or flaxseed meal to young calves, it is probably best to make it into a mash with boiling water and keep it hot for an hour or two before feeding. This should drive off any prussic acid that might be formed and thus prevent any risk of poisoning.

Flaxseed.—Flaxseed is too expensive to use in the feeding of mature cattle, but it is sometimes used, in the form of a meal, for the feeding of young calves. It has a high content of protein and oil and has a laxative action which is very valuable. It is too expensive to be widely used, however. It is used to a slight extent, in the ground form, with cows that are being forced for records.

Linseed-oil Meal.—This is the ground product obtained after the extraction of the oil from the flaxseed. It is a widely used and valuable feed. There are two varieties of it,

the old process and the new process. The old-process oil meal is the ground product obtained after extraction of part of the oil from the flaxseed by crushing, cooking and hydraulic pressure, while the new-process oil meal is the ground product obtained after extraction of part of the oil from the flaxseed by crushing, heating and the use of solvents.

The oil extraction is more complete in the case of the new-process than in the case of the old-process meal, therefore the old-process meal contains rather more oil and less protein than does the new-process meal, and is rather more valuable. Owing to their similarity there is danger of substitution, but the following simple test makes it easy to distinguish between them. Put a little of the finely pulverized meal in a glass and to it add ten times its volume of boiling water. Stir thoroughly and allow to stand undisturbed for an hour. If the meal settles to the bottom and leaves the water clear, it is new-process; if the mixture remains jelly-like, it is old-process meal.

Old-process linseed-oil meal is one of the best feeds for dairy cows. It contains a large amount of digestible nutrients and has a laxative and cooling effect upon the digestive system. It is a very safe feed, and though its relatively high price sometimes causes it to be a less profitable source of protein than some other feeds, it is often advisable to use it, in spite of its high price, for calves, bulls and animals that are off feed, in low condition or being prepared for freshening or Advanced Registry tests. One or 2 pounds per day makes an excellent addition to a ration. The old-process meal contains 3 per cent less crude protein and 4.5 per cent more fat than does the new-process meal, is more digestible and also has a better effect on the digestive system. It should be fed instead of the new-process if the difference in price is not too great.

COCONUT MEAL

Coconut, or copra, meal contains about 18 per cent of digestible crude protein, and its fat content varies considerably. It is a feed that has given good results in Europe and also on the Pacific coast, the main section of this country in which it has been tried. Many claim that it will cause a temporary increase in the fat content of milk. It is very palatable when fresh, but tends to become rancid if stored for long periods. Even though it has a lower protein content, it is perhaps almost as valuable as oil meal for dairy cows.

PALMNUT MEAL

This feed, like coconut meal, has not been used much in this country, but has been used successfully in Europe. It contains less protein and fat, as a rule, than does coconut meal.

CHAPTER XVII

MISCELLANEOUS CONCENTRATES

Most of the feeds used for dairy cattle are of vegetable origin; a few of these that cannot be conveniently discussed elsewhere are included here. There are also feeds derived from animal sources, some of which are very valuable and universally used, though some are of little importance. With these standard concentrates are also included the proprietary feeds, of which there are a multitude.

BUCKWHEAT AND ITS BY-PRODUCTS

Buckwheat is frequently classed with the cereals, but it does not belong there as it is a polygonaceous plant. Buckwheat itself is seldom used in the feeding of dairy cattle, and the buckwheat by-products are not of primary importance. Buckwheat middlings make quite a good feed as they are fairly palatable and contain over 28 per cent of crude protein. Usually, however, they are mixed with the hulls and sold as buckwheat feed, which is rather unpalatable and though slightly less valuable than bran is used to some extent. Frequently, too many hulls are added to the mixture, and this results in a feed of high fiber content and little value.

MOLASSES

Molasses is a valuable carbohydrate feed, but it is frequently too high in price to be used economically in general herd feeding. Beet and cane molasses differ little in composition.

Each contains about 65 per cent of nitrogen-free extract, nearly all of which is digestible, and only a small amount of crude protein which, consisting largely of amides, is of doubtful nutritive value; neither contains fat or fiber. Though both types of molasses are laxative in character, the beet molasses is sometimes more purgative in action on account of the presence of alkaline salts, organic acids and other substances.

Molasses cannot be conveniently fed alone, and it is usually mixed with, or poured over, other feeds and is frequently diluted with water before being used. Though it cannot always be used economically it is frequently to be advised where inferior or unpalatable feeds have to be utilized, as under such circumstances it will cause the animals to make good use of feeds which might otherwise be wasted. An addition to the ration of 2 to 3 pounds of molasses per head per day is frequently of advantage in such cases. It can also be used satisfactorily where cows are being forced for production, and maximum feed consumption is desired.

DAIRY PRODUCTS

Milk and the by-products obtained in the manufacture of butter and cheese are used for the growing of calves but not generally for older animals. The efficient use of these feeds means a large addition to the income of the farmer. Owing to the fact that they are generally easily obtainable, their true value is frequently overlooked.

Whole Milk.—This is undoubtedly the best feed for young calves, as it supplies them with the nutrients they need in the right proportions, but it can seldom be used economically in the raising of calves as the market price for whole milk or butter fat is usually sufficiently high to bring in greater returns than can be obtained by the feeding of the whole milk to calves. In spite of this, it should be supplied to the calves during their first few weeks of life.

Skim Milk.—Calves can be successfully reared on skim milk, provided the feeding is done intelligently. Skim-milk calves are not always in as good condition as are calves fed on whole milk, but the gains in live weight can be obtained more economically and the animals will develop into as good cows as those fed by the more expensive method. The taking of the butter fat from the milk does not render it valueless for calf-feeding, but substitutes should be provided for the materials removed, and this is generally most efficiently done by the supplying of grain.

Buttermilk.—Buttermilk, when obtained fresh and undiluted, is just slightly lower in value for calf-feeding than is skim milk. Care should be taken to prevent it from deteriorating before it is fed.

Whey.—Fresh undiluted whey can be successfully employed in the feeding of calves, though its value is not more than half that of skim milk. It should be remembered that whey, unlike skim milk and buttermilk, is not a high protein feed, as it contains less than 1 per cent of digestible crude protein and more than 5 per cent of digestible carbohydrate equivalent, while skim milk contains 3.5 per cent of digestible crude protein and 5.5 per cent of digestible carbohydrate equivalent. Consequently, the supplementary grain fed with it should be of relatively high protein content.

Dried Dairy Products.—Various brands of dried milk, skim milk and buttermilk are to be obtained on the market. These are in powdered or semi-solid form and can be successfully used in the feeding of calves when the prices asked for them are not too high. As a general rule they are not advisable where skim milk is available, though they are frequently of value in the market milk regions where all of the product from the cows is marketed.

PACKING-HOUSE BY-PRODUCTS

The packing-house by-products are concentrates of very high protein content and of considerable importance in the feeding of live stock. Up to the present time, however, they have not been used to any considerable extent with dairy cattle and they will probably never become popular for this purpose.

Tankage.—Tankage is seldom used as a dairy cow feed in this country, but in Europe good results have been obtained when it was fed to milk cows at the rate of 2 to 3 pounds per thousand pounds live weight. It will probably never be popular as a dairy-cattle feed in this country, owing to the high price it commands for hog-feeding purposes, and the large supply of more popular protein feeds. Its palatability to dairy cows is also much in doubt.

Blood Meal.—It has been found that, pound for pound, blood meal is twice as valuable as cottonseed meal for milk-producing purposes. It is not commonly fed to dairy cows and will probably never be popular. When it is used, it should never be given in amounts greater than 1 to 2 pounds per head per day. At the present time many are advocating its use for calf-feeding, and it seems to be giving good results when used as a constituent of milk substitutes, as it has a tendency to prevent scours.

FISHERY BY-PRODUCTS

The fishery by-products are not of much importance as dairy-cattle feeds, but there is a possibility that they may be of greater importance in certain sections in the future. They are used to a considerable extent in Europe at the present time. They are rather unpalatable to dairy cows and if not fed carefully may impart a disagreeable odor to the milk.

Fish Meal.—This generally contains less protein and fat than does good tankage. It is fed to cows to some extent in

Europe and it is reported that when it is fed at the rate of about 2 pounds per head daily it produces no bad effects on the milk and is of about the same value as cottonseed meal, though the Federal Department of Agriculture reports that it is about 20 per cent more valuable than cottonseed meal.

Whale Meal.—This is used for dairy cattle-feeding in Europe to some extent, but is of no great importance in this country, its value and future prospects being perhaps about the same as those of fish meal.

PROPRIETARY FEEDS

In some cases the man in charge of live stock believes that he does not possess the knowledge necessary to choose his concentrated feeds to the best advantage, while in other cases the farmer prefers to buy ready-mixed feeds and thus be saved the trouble of compounding the grain ration for his cows. As a consequence there are now a large number of proprietary mixed feeds on the market. Proprietary feeds cannot be favored or condemned as a class, but need individual consideration.

Standard Feeds.—These usually consist of well-known concentrates sold under trade names. Generally only one constituent is present, some of the feeds that have been sold in this way to a considerable extent are brewers' dried grains, distillers' dried grains, gluten feed and cold-pressed cottonseed cake. They are usually valuable feeds and when sold at reasonable prices can be recommended for the feeding of dairy cattle.

Mixed Concentrates.—A large number of manufacturers put on the market feeds that are mixtures of good concentrates; practically any of the common feeds can be found in such combinations. They are usually good feeds and can be bought with safety when the price paid for them is in proportion to the amount of digestible nutrients they contain.

Occasionally valuable concentrates are used to mask the presence of worthless waste materials which could not otherwise be disposed of.

Alfalfa-molasses Feeds.—There are on the market many feeds the basis of which is ground alfalfa hay or alfalfa meal. They usually contain some molasses. Practically any of the common concentrated feeds, as well as a large number of useless materials and adulterants, can be found in combination with the basal materials.

Many of these feeds, put out by reliable firms, are made from good alfalfa hay and concentrates of high quality. Such feeds are legitimate, and their sale cannot be criticized as long as they are priced in accordance with the amount of digestible nutrients they contain—a reasonable allowance being necessarily made for the preparation of the feed. On the other hand, quite a number of alfalfa-molasses preparations are made from very poor quality alfalfa hay, or even alfalfa straw, flavored with molasses and containing rather negligible amounts of concentrates. Damaged grains, mill refuse and other materials of doubtful feeding value are also used in their elaboration. Feeds of this nature have no place on the dairy farm.

Peat-molasses Feeds.—The handling of molasses is difficult, and some feeders prefer to have their work simplified through the absorption of the feed by peat. Peat-molasses feeds are perhaps convenient to handle, and the trade in such materials is no doubt legitimate when they are sold for what they are—molasses absorbed by peat. However, some firms make extravagant statements regarding such mixtures and even attribute a direct feeding value to the peat. Such statements are unwarranted.

The peat used in the preparation of mixed feeds may contain as high as 25 per cent of moisture, and the buying of water in mixed feeds is always expensive. The claim is

frequently made that the peat will neutralize any free acids present in the molasses; but peat is in itself acid in reaction and so cannot neutralize any acid that might be present in the molasses. Moreover, neither cane nor beet molasses is acid in reaction, as a general rule.

Where the ash content of peat has not been affected by wind- or water-borne materials, during its formation, it will be low and of little consequence as far as the animal economy is concerned. On the other hand, many peats have a high ash content due to the deposition of sand at the time of their formation. Some peats are known to contain over 10 per cent of sand; if these were fed to animals they would be harmful rather than beneficial, as the large amount of sand would produce intestinal irritation leading to scours, and might even result in the death of the animals.

The fats or oils in peat are practically negligible in quantity and are very probably not available to animals. At times the dry matter of peat may contain about 1 per cent of fatty material, a small portion of which might be digestible.

The materials from which peat is derived contain proteins; but these are to a great extent broken down during the process of peat formation and give rise to simpler non-protein nitrogenous compounds. It has been shown that, as a rule, the dry matter of peat contains less than 2.6 per cent of nitrogen and that 6.6 per cent of this nitrogen might be digested by animals. If this nitrogen that might be digested were protein nitrogen, the highest amount of digestible crude protein that could occur in peat would be .8 per cent, but as this nitrogen is undoubtedly mainly, if not entirely, non-protein nitrogen, it is evident that peat cannot be looked on as a protein concentrate.

Of the carbohydrates in peat, practically none of the nitrogen-free extract is available. A small amount of the pentosans may be available, but they are of doubtful value.

The fiber has still to be accounted for. The dry matter of peat may contain as high as 25 per cent of crude fiber and some of this is at times digestible. The digestion of this fiber, however, is a net loss, rather than a gain, to the animal as more energy is required to digest and assimilate fiber than the fiber itself provides.

The excessive amount of fiber present, in comparison with the other constituents, nullifies any nutritive effect these might have, as the digestion of the fiber uses up more energy than could be provided by the small amount of other nutrients that might be present. The fact that some digestible nutrients may be present is no real indication that peat has a positive nutritive value, because the efforts expended by the animal in obtaining these nutrients cause the use of more energy than the nutrients furnish.

It has also been shown that peat not only possesses no nutritive value in itself, but also depresses the digestibility of the substances with which it is fed. This is due to its high fiber content. Consequently, it may be said that, though peat is a convenient agent for the absorption of molasses, it possesses no inherent nutritive value of its own and may even depress the digestibility of the other constituents of the ration.

Fillers.—Many mixed feeds of little or no value are on the market. They are usually composed of waste materials which cannot be disposed of in any other way, sometimes with the addition of constituents which will increase their apparent content of protein and substances which will impart to them a pleasing aroma and an appetizing flavor.

Some of the substances frequently used in the manufacture of such preparations are mill sweepings, ground corncobs, cottonseed hulls, oat hulls, flax-straw refuse and ground peat. The majority of these materials are absolutey devoid of feeding value, and in some cases they may contain so much

grit and sandy material as to be dangerous when fed to live stock. Feeds of this type should not purchased at any price.

Tonic Feeds.—The so-called conditioners, tonics, or stock feeds are not needed, though the majority of them are harmless. They frequently consist of inert materials to which have been added such common and cheap ingredients as common salt, sulphur, charcoal, alum, copperas, Epsom salts and Glauber's salts, occasionally with aromatic substances such as fennel and anise seed.

When the low cost of the ingredients is considered, the prices asked for the majority of stock tonics are exorbitant. If they fulfilled the claims made regarding their curative properties such prices might be justified. However, they do not fulfill such claims. An idea of their low initial cost and impotence as cure-alls can be obtained from a knowledge of the fact that some of them contain as much as 85 per cent of common salt.

Some of the feeds called tonics do have medicinal properties, but it is a slur on the common sense of the stock-owner to ask him to believe that one highly odoriferous powder will cure all animal ills. Such a claim is especially preposterous in the light of the fact that specific ills require specific treatment, and even animals have their own individual requirements in health as well as in sickness.

Stock tonics should not be purchased at any price, for the simple reason that an animal in good condition needs no tonic, and an individual that is off feed or otherwise out of order can be treated by cheaper and more effective methods.

All proprietary feeds should be bought on the basis of their digestible nutrient content and not on the claims made for them. Where possible, a statement of the constituents from which the mixture is made should be obtained, as this is very frequently a good indication of the probable value of the feed.

PART V

FEEDING PRACTICE

CHAPTER XVIII

GENERAL FEEDING CONSIDERATIONS

In feeding the dairy herd the greatest attention is necessary in the care of the milking cow and the young calf. Much care is demanded by members of these groups which is not absolutely necessary in the case of other animals. The main problem is the same throughout—that of getting maximum results at the lowest cost possible. Consequently, many of the problems mentioned here will apply to other classes of dairy stock in addition to the milk cow.

Each cow has her own individual requirements for maintenance and production; moreover, attention must be paid to the likes and dislikes of the animals if the maximum or most profitable production is to be obtained. The cow should receive an abundance of feed containing plenty of nutrients in the correct proportions and made up of feeding stuffs that she likes. The consideration of economy is essential, in view of the relatively high prices generally demanded for certain types of feeding stuffs. In the major portion of the dairy regions, and especially in the corn belt, the chief feeds that have to be purchased are high protein concentrates, and in buying these the relative cost of the digestible protein in the various feeds should be determined and considered. Other things being equal, the concentrate providing digestible crude protein at the lowest cost per pound should be purchased.

The feed of a cow must be regulated by her production, live weight and condition. Enough feed should be provided to keep the cow producing to the best of her ability and in fair

condition. She should not be allowed to become poor or too fat. When poor in condition the cow is evidently not getting enough feed for both maintenance and production and is drawing on her body for nutrients to keep up her milk yield. This cannot go on indefinitely, however, and when the body stores of nutrients have been depleted to a certain level milk production must be curtailed. Excessively high condition, except at the beginning of the lactation period, also causes a decrease in milk production.

The production of a cow should be determined by means of the milk scales and the Babcock tester, and with their "advice" the feeding operations can be conducted intelligently. As a rule the grain ration will be determined by the production, and the roughage ration by the live weight of the cow. One pound of grain can generally be fed for each 3 to 4 pounds of milk produced, depending on the richness of the milk and the total amount produced. Another simple method of determining the grain requirements is to allow 7 pounds of grain for each pound of butter fat produced. High-producing cows require more grain than do low producers. As a rule the amount of roughage required per thousand pounds live weight will be about equal to 25 to 35 pounds of silage and 10 to 15 pounds of legume hay per day.

The live weight of a cow is a good index as to whether she is being properly fed or not, but good judgment or, better yet, accurate scales must be used in determining the live weight. The weight of a cow varies considerably from day to day and at different times during the day, largely because of differences in intestinal fill and in the length of time before or after feeding and watering.

The weight of a cow should not be expected to remain constant throughout the lactation period, as under average conditions she will decrease in weight for the first six to twelve weeks after calving. This post-parturient live-weight

decrease depends largely on the condition of the cow at the time of freshening and on her inherent ability to take the stores of fat from her body and use them for milk production. The greater this ability is, the greater will be her decrease in weight after freshening; in some cases it amounts to 200 and occasionally even to 500 pounds.

After this initial loss, the cow will remain practically constant in live weight for some time, depending largely on the time of her next freshening. For a period of from two to five months previous to calving the cow may be expected to increase in weight. Only a small portion of this increase, however, is due to the growth of the fetus, the remainder being due mainly to the storage of body fat which will later be used for milk production.

Heifers during their first and second lactation periods require heavier feeding proportionately than do mature cows. The very obvious reason for this is the growth of the animals. The Guernsey cow, Imp. Parson's Snowdrop IV, at Iowa State College, averaged 872 pounds in live weight in her first lactation period, and during her fourth period of production she weighed, on the average, 1053 pounds. This shows an increase of 21 per cent in live weight; nutrients must be supplied in the ration to take care of this growth and to build up new body tissues. After the fourth lactation the weight of this cow remained fairly constant from year to year, though in the case of some cows full growth may not be reached until a somewhat later age.

A cow with a beefy tendency generally requires a ration of a narrower nutritive ratio than does one possessing the nervous temperament so much sought. Two Holstein cows at Iowa State College, Snowflake Josephine DeKol II and Lucy Duchess DeKol, were of practically the same age and had always received the same general treatment, but Snowflake Josephine DeKol II had a decided tendency to put on

body fat while Lucy Duchess DeKol showed much greater refinement and was difficult to get into high condition. On one occasion when they freshened at about the same time, Snowflake Josephine DeKol II received a ration with a nutritive ratio of 1 : 4.2 for a part of her lactation period while for a similar period the ration of Lucy Duchess DeKol had a nutritive ratio of 1 : 5.0. Even with such rations, Snowflake Josephine DeKol II remained in much higher condition than did the other cow. This is due to the fact that the cow with her milk-producing ability well developed tends to use her feed for milk production while the animal with this power less highly pronounced tends to use the feed for the production of body fat; consequently the beefy animal must have this tendency counteracted, as far as possible, by the feeding of extra protein to stimulate milk production, while the other animal must be fed an additional amount of carbohydrates and fats in order that her store of body nutrients may not be depleted to a considerable degree.

TABLE XIII

Increase in Live Weight Due to Maturity of Guernsey Cow, Imp. Parson's Snowdrop IV

Lactation	Age at Freshening	Average Live Weight Pounds
1	2 yr. 5 mo.	872
2	3 yr. 6 mo.	966
3	4 yr. 0 mo.	1018
4	5 yr. 0 mo.	1053

Though liberal feeding is essential, overfeeding must be strictly guarded against, as it will cause a considerable amount of damage. A very good example of this is obtained from part of the feed and production record of the Iowa State College Guernsey cow, Imp. Rouge II of the Brickfield.

TABLE XIV

OVERFEEDING OF THE GUERNSEY COW, IMP. ROUGE II OF THE BRICKFIELD

Date	Ration Fed										Milk Produced. Pounds.
	Cracked Corn. Pounds.	Wheat Bran. Pounds.	Gluten Feed. Pounds.	Oil Meal. Pounds.	Ground Oats. Pounds.	Dried Beet. Pulp. Pounds.	Corn Silage. Pounds.	Alfalfa Hay. Pounds.	Total Concentrates. Pounds.	Total Roughage. Pounds.	
April											
16	4	3	3	3	4	2	30	10	17	42	36.5
17	4	3	3	3	4	2	30	10	17	42	33.5
18	4	3	3	3	4	2	30	10	17	42	23.9
19	4	3	3	3	4	2	30	10	17	42	16.2
20	....	2	....	2	2	1	20	8	6	29	15.2
21	....	2	....	2	2	1	20	8	6	29	25.0
22	....	2	....	2	2	1	20	8	6	29	26.0
23	3	1	2	3	2	1	25	8	11	34	29.3
24	3	1	2	3	2	1	25	8	11	34	30.2
25	3	1	2	3	2	1	25	8	11	34	33.6
26	4	2	2	3	3	1	25	8	14	34	34.3

This cow was giving about her normal production on April 16th and was being fed 17 pounds of concentrates or 1 pound of grain for each 2 pounds of milk produced, which was about 3 pounds more of grain than she required. As a consequence she went off feed and decreased rapidly in production. Her grain ration was markedly reduced on April 20th, though it should have been reduced about two days earlier; her grain then consisted only of bran, oil meal and ground oats, which are valuable concentrates under such circumstances. Her milk production had now reached the low level of 15.2 pounds per day, but after the grain ration was so markedly cut her appetite recovered and her production immediately increased. Her ration was increased to keep pace with her production and by April 26th she had come back to about her normal production and was receiving 14 pounds of grain or about 1 pound of grain for each $2\frac{1}{2}$ pounds of milk produced. This was ample and allowed her to produce to the height of her ability without being pushed heavily.

This shows that too heavy feeding will throw a cow off feed very rapidly and that this will bring about a decrease in milk production. When a case of overfeeding is discovered the grain ration should be immediately cut down, only such feeds as bran, oil meal and ground oats being provided. After a few days the grain may be increased gradually as the cow regains her appetite. It is very frequently advisable to eliminate the grain ration entirely and replace it with a bran mash.

The aim in feeding milk-producing cows is to have them consume the maximum amount of feed, in excess of that required for the purpose of maintenance, and use it for the production of milk; but at no time should the animals be overfed. All feed should be cleaned up in a comparatively short time—this is especially true of silage and concentrates

—and feed that has been refused should be removed as soon as possible. It is only in this way that the manger can be kept clean and the cows prevented from going off feed.

In feeding dairy cows it should be remembered that the individual cow is the unit of profitable production, and for the very best results the cows should be fed individually. The requirements of different cows vary, and those of any one individual also change considerably from time to time. No matter what system of herd feeding is practiced, the results obtained will not be the best possible unless great attention is given to the individual requirements of the different animals in the herd. This is especially important in the case of the producing cows, but it also holds true, though to a smaller extent, in the case of the dry cows and the growing heifers which will later take their place in the milking herd.

CHAPTER XIX

SUMMER MILK PRODUCTION

Summer conditions are frequently looked on as the most favorable for economical milk production, and in a general way this is true, especially in high latitudes, though in other sections the heat may be great enough to counteract the beneficial influences. In the greater portion of the United States, maximum milk production is usually obtained during the early part of summer, the flow reaching its greatest magnitude shortly after the cows are turned on pasture. This suggests that at this season the conditions are most favorable for milk production and that similar conditions should be maintained, as far as possible, during the remainder of the year. The influences which render early summer conditions almost ideal for milk production are an abundance of succulent, palatable pasture which provides nutrients in plenty, and the equable climatic conditions of that period.

Turning cows to pasture not only cuts down the expenditures of feed and labor to considerably below what they are in the winter time, but it stimulates the production of the cows, not only for the short time immediately after they go on pasture, but also for the remainder of the lactation period.

In changing the cows from winter feed to pasture it is best to proceed slowly, especially in the case of heavy-milking cows, as the young, immature grass of early spring contains a very small amount of dry matter, and it is difficult for a heavy-milking cow to consume enough of such feed to supply the

nutrients necessary for maintenance and production, while amides and other compounds present in young grass may tend to cause scouring. If the cows are put on the pasture too suddenly the flavor of the milk is also adversely affected.

When the milking herd is turned out to pasture the winter roughage must be cut down rather rapidly and the grain ration more slowly. The feeding of a little hay for a short time after the cows are put on pasture helps to counteract the laxative action of the young grass. As soon as the cows have become accustomed to pasture, all other feeds can be eliminated except in the case of heavy producers, and even they should not receive more grain than is absolutely necessary for the maintenance of their production at its normal level.

The elimination of grain from the ration for the first four to six weeks after the cows are turned on pasture has everything to recommend it. The absence of concentrates from the ration at this time allows the digestive system of the cow to rest, and she is in better condition to handle grain when the feeding of it again becomes necessary.

Though the cows of average producing ability will be amply supplied with feed from the pasture alone during the early part of the grazing season, the pastures in many sections do not furnish enough feed for the cattle during the hot, dry weather of late summer and fall. The problem of supplying additional feed may be met by better care of the pastures, by the provision of more pasture, by using larger quantities of concentrates or by providing succulence in the form of silage or soiling crops.

It is generally advisable to have some pasture for the cows, but under some conditions good results can be obtained without it. The pasture should be kept producing to its greatest capacity, but even under the most favorable pasture conditions it will usually be found advantageous to provide additional feed.

During late summer, pasture alone will not provide the necessary nutrients demanded by high producing cows, which require some grain in order that they may continue producing to the best of their ability. Medium or mediocre producers will not yield much more milk when fed grain on pasture, and the additional yield will not, as a rule, pay for the grain. It has been shown at the Cornell Experiment Station that cows which are fed grain during the summer will produce better during the succeeding winter than those which receive no concentrates; consequently, when cows are above the average in production the best policy will usually be to feed grain, at least during the latter part of the pasture season.

Feeds suitable for summer feeding are cracked corn, ground oats, and cottonseed meal. They keep the cow up in production during the hot weather and aid in building up her body to withstand the strain of continued milk production during the succeeding winter. Cottonseed meal, being constipating in action, also counteracts the laxative action of washy grass. Where cows or pasture are receiving only a small amount of grain, corn is as good as any other concentrate, as with the pasture grass it provides a fairly well-balanced ration—provided, of course, that it is as cheap as other grains; but when cows are getting large amounts of grain, 5 pounds per day or more, other feeds, nitrogenous in character, should be used, and under such conditions cottonseed meal is to be recommended.

Granting that the pastures are well tended, and the grain feeding judiciously handled, the fact remains that these two factors are not sufficient to maintain maximum economical milk production during the hot, dry months of summer. During this period three factors contribute toward lessened milk production, a lack of succulent feed, warm weather and flies—and of the three the first is the most important. The majority of dairymen are agreed that the loss occurring at

this time from lack of suitable feed exceeds that occasioned by improper winter feeding. In summer, when the cows are on pasture and field work is pressing, many men neglect their cows, while in winter the owner expects to feed his stock and is prepared for it.

Under average dairy conditions the cows freshen in the spring, and give a good yield of milk while the pastures last; but when hot weather and dry grass come the flow decreases one-half to two-thirds, and the cows are almost dry at the beginning of winter. It is almost impossible to restore the flow of milk to the original level after it has once been allowed to run down from lack of suitable feed. To make large returns from the cow, the yearly production must be maintained at a high level, and to secure this it is essential to prevent the summer drop.

Where the cows freshen in the fall the greatest milk yields can be obtained, as a good flow will be maintained during the winter and the advent of pasture in the spring will prevent a large drop in production and keep the yields fairly uniform. Then when dry weather comes some provision must be made to supplement the dry pastures and prevent a too rapid decline in milk flow. Heavy grain feeding will accomplish this fairly well, but it is unnecessarily expensive, and provision should therefore be made to have green crops on hand that can be cut and fed as needed or to have silage available.

CHAPTER XX

SILAGE VERSUS SOILAGE

Providing succulence to supplement the dry pastures of summer has been found to be an essential of economical milk production in a very large number of dairy sections, and the decision as to which method shall be followed—whether it shall be silage or soilage—to maintain the summer milk flow is an important one. The choice between them will depend largely on individual conditions, and a knowledge of the main factors concerning each system of feeding is needed before an intelligent selection can be made.

ADVANTAGES OF SILAGE

Feeding Economy.—On the average farm, corn silage can be produced cheaply and is a more economical feed for milk production than is soilage. It has frequently been stated that soiling crops will induce greater individual production in a herd than will silage, but this is very doubtful; and it is certain that the cost of production per hundred pounds of milk will be less in the case of silage than where soiling crops are used. As economy of production is the most important item demanding the attention of the practical dairyman, it will generally be found that, where either soiling or silage can be used for summer succulence, the best practice will be to use silage, though in some cases both are fed.

Labor Saving.—The harvesting of silage is performed at a time when the labor shortage is not generally as acute as it is at other seasons, whereas soiling crops must be harvested

at the very busiest time of the year. This is in favor of the silage as a summer feed; in addition, the labor entailed in the actual feeding of silage is considerably less than in the feeding of soiling crops. This factor is of most importance where labor is scarce and the greatest production per man is desired.

Where soiling crops are fed, they must be cut and hauled to the barn daily, and in wet weather this renders labor conditions disagreeable. Any factor which makes work disagreeable really increases the labor requirements, and as silage can be fed as conveniently in wet as in dry weather, the advantages of silage over soiling crops on this account are evident.

Feed Reserve.—Silage possesses the added advantage of keeping for a relatively long period of time. While some silage is spoiled by age, the greater portion remains in a desirable condition. It does not become unpalatable, as do soiling crops when maturity is reached, and it does not fluctuate in feeding value from that of a light, washy feed to one of a more mature and dry nature. Where silage is stored, an excess of feed from one year can be conveniently kept until a season of feed scarcity, when it will still be in good condition. This prevents a shortage of summer succulence through crop failures.

DISADVANTAGES OF SILAGE

Lack of Variety.—A lack of variety in the succulent portion of the ration may become evident when silage is fed throughout both winter and summer. This becomes increasingly important when silage constitutes the main part of the summer succulence. The deficiency of the corn plant in ash may also prove important, unless due attention is given to the mineral content of the other feeds supplied. Furthermore, silage is deficient in protein, and feeds containing a considerable amount of protein must be used in liberal quantities where silage is fed extensively at all seasons.

Necessity of Small Silo.—The principal disadvantage of silage as a summer feed is the small size of silo required. Silage, to be of good quality and palatable, must be removed from the silo twice as rapidly in hot weather as during the winter months. The silo must therefore be of smaller diameter, involving additional expense in the saving of the crop. Where a large herd is maintained this will necessitate the building of small silos which are difficult to locate conveniently, as well as costly to erect. Since the silage must be fed rapidly in summer, there are many herds which are not large enough to warrant the erection of a summer silo. The small silo costs more in proportion to its capacity than does the large one, and in addition permits a much greater proportion of the silage to spoil around the edges of the silo. For this reason many of the arguments advanced for the feeding of summer silage do not apply to the small herd.

ADVANTAGES OF SOILAGE

Intensity of Production.—Through the utilization of soiling, the production of digestible nutrients per acre can be increased from three to five times over that produced by pasturing This is primarily due to the heavy yields which can be obtained with soiling crops, and it is really a conservation of land as it decreases the acreage necessary for the support of a given number of cattle, or allows a greater number of animals to be maintained on a given area. In soiling, the land is not subjected to the tramping that a pasture receives from the cattle; not only is the elimination of the waste due to tramping and puddling possible, but the land is also kept in better condition and the losses due to fouling and the uneven distribution of manure are prevented. In some cases also, two crops per year can be grown, and this increases feed production. The saving of land by soiling has been frequently demonstrated, and as the result of seven years' work at the

Iowa Station it was found that forty-two milking cows could be kept during the summer months on 20 acres of pasture and 12 acres of soiling crops.

In this Iowa work the average length of the pasturing season was one hundred and sixty-seven days, and soiling was fed on the average for one hundred and eleven days, the average consumption of soilage being 1.93 tons per cow per season. The average cost was $5.30 for soiling and $3.30 for pasture, or a total of $8.60 per cow per season. This compares well with a cost of $12 to $18 per cow per season, which would have resulted from the use of pasture alone. The cost of grain has not been figured in either case, but it would of necessity have been greater if the pasture had not been supplemented with soiling crops.

Manure is one of the valuable products of the farm that is frequently neglected and allowed to go to waste. Where the cows are on pasture the manure is very unevenly distributed, and so is not effectively used, but where it is hauled on to the land to be used for the production of soiling crops it is utilized to the greatest advantage, increases the yields obtained from the farm and adds to the fertility of the soil.

The feeding of soiling crops not only increases the number of animals that can be kept on a given area, but it also stimulates the production of the individual members of the herd. This increase in production, combined with the lowered cost of production per unit, adds considerably to the net income from the farm.

In many systems of farming a large amount of the feed produced is wasted and not consumed, but by the use of a good soiling system this can be avoided. When suitable soiling crops are grown they are utilized very thoroughly and feed wastage is prevented.

Small Intital Outlay.—Where soiling is practiced no large initial outlay is called for, and this recommends it under many

conditions where the building of a silo is not warranted or must be postponed. For the small herd that cannot support a silo, soiling has to be recommended on this account.

Variety in the Ration.—The variety introduced into the ration through the use of soiling crops is of great value. Variety is as valuable in the succulent portion of the ration as it is elsewhere, for not only does it insure an abundance of ash constituents and the proper variety of proteins, but, in addition, a variety of succulent feeds stimulates the appetite of the cow, increases her feeding capacity, keeps her digestive system in good working order and has a beneficial effect on her general health. This not only gives a temporary increase in production, but also leads to greater milk yields during the succeeding winter.

Sometimes pastures are badly infested with garlic and other weeds which tend to taint the milk. The use of soiling crops with a limited amount of pasture will check this nuisance. Occasionally it will be necessary to feed soiling alone, without pasture, until the weeds can be brought under control, but on the whole the elimination of pasture is not a good practice as there are benefits to be derived from it which cannot be obtained otherwise.

DISADVANTAGES OF SOILAGE

Labor Requirements.—Soiling crops must be sown in comparatively small areas, as a considerable number of sowings are needed to keep the supply of green feed ample and regular throughout the season. These small plots increase the labor requirements of seeding and growing the crops, but the main drawback to a soiling system is the large amount of labor needed in the harvesting of the feed.

The green feed, to be in the most palatable and appetizing condition, must be cut and hauled to the barn daily, as feed that is stored in the barn will ferment and spoil very rapidly.

Even in a system of partial soiling, which is the common practice, and with a fair amount of pasture available, the cows will consume from 30 to 70 pounds of green feed per head daily; consequently the labor involved is considerable. For a partial soiling system, with a herd of forty cows, two men and a team will be required for two hours daily to cut and haul the green feed to the barn. In addition more labor is needed in the barn in feeding soiling than in feeding silage. This heavy demand for labor, at the busy season of the year, militates against the use of soiling in many cases.

Succession of Succulence.—To have the requisite amounts of green feed available at all times is a difficult problem. The varying climatic conditions and the consequent changes and inequalities in the rates of ripening of the various crops render the time at which a given crop may be available variable. The average yield of a crop, and therefore the exact acreage, needed to supply sufficient green feed for a herd during a given period of time, depends largely upon the weather conditions; where there must be a succession of crops furnishing the soiling, it is oftentimes undesirable to utilize any surplus for hay production, which is the only alternative presented.

The time during which a soiling crop can be used depends on the character of the crop, the time at which it is sown, the soil and climatic conditions. Some crops, such as alfalfa, are adapted for use as soiling during comparatively short periods, after which the forage becomes too mature for feeding, while other crops are available for use through quite a long period. Thus, the task of meeting the needs of the herd, under changing climatic conditions which influence the yield and time of ripening of the crop as well as the length of time during which it may be fed, is a difficult one, and is worthy of serious study on the part of the dairyman.

SILAGE OR SOILAGE

The relative merits of silage or soilage for supplementing the dry pastures of summer are in dispute. The advisability of furnishing additional succulent feed in summer is appreciated, and undoubtedly there are conditions under which both feeds may be profitably fed. Either silage or soilage is essential for economical milk production in summer in many sections, and a choice between them will depend on individual conditions.

On the average farm, silage is the more economical form of succulence. and is generally to be recommended, while on small farms soiling should be used if the number of cows is not large enough to warrant the erection of a silo for summer use. On the large farm the summer silo can generally be recommended, but if plenty of help is available a larger number of cows can generally be supported by growing soiling crops than be feeding summer silage, though silage will give cheaper milk production than will soilage.

Investigations conducted at the Iowa Station over a period of two years give a very good indication of the relative values of silage and soilage for summer milk production. Throughout both seasons, records of the feed consumption and milk and butter-fat production of the cows were kept. The succulent feeds were fed according to the capacity of the animals, while the grain rations were controlled by the production of milk and butter fat. All animals were at pasture, and the grain rations were fairly liberal, especially during the second year when a large number of the animals were being prepared for fall freshening.

A total of sixty cows were used, and in each year the feeding period was divided into three sections. In the first year the silage was fed in the middle period and the soilage in the first

and last periods. In the second year the feeding periods were reversed. Only a brief summary of the results can be given.

TABLE XV

TOTAL FEED CONSUMPTION AND MILK PRODUCTION IN A COMPARISON OF SILAGE AND SOILAGE AS SUMMER SUCCULENCE

Succulence	Total Feed			Total Production		Average Live Weight of Cows, Pounds
	Grain, Pounds	Pasture, Cow Days	Succulence, Pounds	Milk, Pounds	Fat, Pounds	
Silage..........	16,115	1914	56,904	40,477	1654	1003
Soilage.........	16,487	1914	99,710	40,949	1678	1010

In the tabulations the concentrates were grouped together, and the price used for the mixture was determined from the ruling prices of the various ingredients. The value of the silage was determined from the price of corn, while the cost of the soiling crops used, amber cane and a mixture of oats and peas, was determined in relation to the silage price from comparative work done at the Iowa Station in the relative cost of production of silage and soiling crops. The value of the pasture was similarly determined.

TABLE XVI

INCREASED CONSUMPTION AND PRODUCTION IN SOILAGE PERIODS AS COMPARED WITH SILAGE PERIODS

Increase	Feed		Production		Average Live Weight of Cows
	Grain	Succulence	Milk	Fat	
Total, pounds...	372	43,806	472	24	7
Percentage.....	2	75	1	1	6

It is very noticeable that on the average there is little change in the grain consumption, milk and fat yields, or live weights of the animals; it is, therefore, safe to assume that as high production can be maintained with silage as with soiling crops. On the other hand, it should be noticed that the amount of succulent feed consumed was 75 per cent greater where soiling was fed than when silage was used. It was found that when silage cost \$7 per ton and soiling crops \$4 per ton they were equivalent, as far as economy of production was concerned; in each case the feed cost of production was \$1.60 per hundred pounds of milk and 39 cents per pound of butter fat.

The next point is to determine under what conditions, if any, the one feed will be more economical than the other. This may be done by determining the feeding value of soiling crops as compared with corn, through a wide range of prices.

TABLE XVII

COMPARATIVE VALUES OF SILAGE AND SOILAGE FOR SUMMER MILK PRODUCTION

Corn per Bushel	Silage per Ton	Soilage per Ton
\$	\$	\$
0.50	5	2.90
0.65	6	3.45
0.80	7	4.00
0.95	8	4.55
1.10	9	5.15
1.25	10	5.70

When corn is worth 50 cents per bushel, silage has a value of \$5 per ton and soiling crops are worth on the average about \$2.90 per ton, while when corn rises to \$1.25 per bushel the values for silage and soiling will be about \$10 and \$5.70, respectively, for the purposes of milk production. As soiling

crops cannot be produced on the average for less than \$4 to \$5 per ton, this means that as long as corn is below \$1 per bushel, corn silage will be a more economical source of summer succulence than will soiling crops. This is further emphasized by the fact that only the costs of the feeds in the barn have been taken into consideration and more labor is needed in the feeding of soilage than in the feeding of silage. Under the majority of conditions, therefore, corn silage is to be preferred to soiling crops for summer feeding as it maintains as high yields of milk and butter fat as does soilage and is more economical.

THE SOILING PROBLEM

When it is found necessary or advisable to use soiling crops instead of silage as a supplement to pasture, there are many factors in connection with the production and feeding of soilage which need careful consideration, and care must be taken to adapt the soiling system to the individual conditions.

Production of Soiling Crops.—The chief difficulty in the successful production of soiling crops is in keeping a continuous supply of succulent green feed available throughout the summer. The main factor in determining the success of this attempt is the season, but under even favorable conditions at least four or, better still, six individual sowings should be made for a partial soiling system.

Where possible, the soiling crops should be inserted in the regular rotation of the farm, in the place of corn or small grain. If the farm is large or scattered this will not always be practicable, and then it will be necessary to grow the soilage continuously on some piece of land located conveniently to the barns.

The land for soiling should be well worked and a good seedbed prepared; as large yields are aimed at, liberal use of manure is necessary. This is especially important where con-

tinuous growing of soiling is practiced, as the production of large yields of green feed year after year, without fertilizing, tends to impoverish the soil.

Seeding should be liberal. This is most important with crops such as amber cane, for not only will crops be slightly heavier in some cases with thick seeding, but they will also be much finer in quality. Crops that are seeded thinly tend to produce coarse-stemmed plants which are not relished by stock and result in a large amount of waste. Thick seeding, on the other hand, gives a fine-stemmed succulent forage that is readily cleaned up by the cows with a resultant decrease in waste material.

The harvesting of soiling entails a very considerable amount of labor. The majority of the crops can be cut with a mower and sometimes can be put on the wagon with a hay-loader, but where the yield of green feed is heavy the loader will not be suitable. Amber cane can be cut with a small grain binder as it generally stands up well, and the bundles are much more convenient to handle than is the loose material. Corn, when used for green feed, should be cut with a binder if any large amount is used daily.

The green feed, for best results, must be cut and hauled daily as it wilts readily if left in the field, while if piled up in the barn it heats and spoils quite rapidly in hot weather. The feed is very unpalatable when in either of these conditions.

Feeding of Soiling Crops.—Soilage can be fed either on the pasture or in the barn. Feeding it on pasture is a much more convenient method, entailing less labor, though it has its disadvantages. There is a great waste, as a rule, when the green feed is put out on the pasture, due to the fact that the cows trample and foul it. In addition it dries out rapidly and becomes unpalatable. Where it is spread out the cows are also apt to injure each other in their efforts at feeding. When it must be fed on the pasture, perhaps the best method

is to haul it out just before the cows are turned out. Otherwise the cows wait for the soiling instead of feeding, and when the green feed is taken out the danger of cows being injured is increased.

Feeding in the barn is laborious, but on the whole advantageous. The wastage of feed is cut down, and the cows are more comfortable in the barn during the hot hours in the middle of the day. When they are kept in at this time they are protected from the heat to some extent and they can also be sprayed as a protection against flies.

All of the common soiling crops, with the possible exception of corn, can be conveniently fed in the barn. Owing to the coarse nature of corn it is difficult to feed it in the mangers unless labor is available to cut the bundles; in many cases, therefore, corn can be most easily fed on the pasture, though this does induce a considerable amount of waste.

Where the soiling is given on the pasture it is usually fed only once a day, but when fed indoors from one to three feeds may be given, depending on the amount of labor available and the extent to which soiling replaces pasture in the maintaining of the herd. Generally, however, more than two feedings a day will not be advisable where some pasture is available.

The amount of soiling used daily depends on the crops grown and the quality and extent of the pastures. With a partial soiling system, such as is most generally used, from 30 to 70 pounds of green feed per cow a day will commonly be consumed, in addition to pasture.

In the feeding of soilage care should be taken to avoid the inclusion of large amounts of soil with the green feed. Attention to this point is especially necessary where such sparse growing crops as soybeans are raked into windrows after cutting. Soil particles, adhering to or mixed with the green feed, render it unpalatable and tend to cause digestive dis-

turbances. The feeding of soilage that is wet or fermented is another cause of digestive troubles. Care in handling will prevent the heating or fermenting of the green feed, but owing to weather conditions, which cannot be forecast, it is not always possible to get feed that is not wet. Where the soiling has been cut when wet, it is advisable to limit the amount fed, as the wet feed will often produce scours.

PRACTICAL SOILING SYSTEMS

A large and varied number of soiling systems could be mentioned, but only a few which are simple and practical will be suggested. The areas given in outlining these are those that on the average should prove suitable with a herd of about fifteen cows, provided that ten to twelve acres of pasture are also available.

Simplicity is aimed at in outlining these systems; one is suitable where alfalfa is available, one where sweet-corn stover or green corn can be used and one without corn or alfalfa.

TABLE XVIII

A SOILING SYSTEM WITH ALFALFA

Crop	Area, Acres	Approximate Date of Sowing	Approximate Date of Harvesting	Approximate Yield per Acre, Tons
Alfalfa, first cutting	½	Previous year	June 10–20	8
Oats and Canadian field peas	1	April 5	June 15–July 5	6
Oats and Canadian field peas	½	April 20	June 30–July 10	5
Alfalfa, second cutting	½	Previous year	July 5–15	4
Oats and Canadian field peas	½	May 5	July 10–25	5
Amber cane	1	May 20	July 20–Aug. 20	12
Amber cane	1	June 20	Aug. 15–Sept. 20	12
Amber cane	1	July 5	Sept. 10–Oct. 15	12

TABLE XIX

A SOILING SYSTEM WITH SWEET-CORN STOVER

Crop	Area, Acres	Approximate Date of Sowing	Approximate Date of Harvesting	Approximate Yield per Acre, Tons
Oats and Canadian field peas.	1	April 5	June 10–July 5	6
Oats and Canadian field peas.	1	April 25	July 1–25	5
Amber cane.	1½	May 20	July 20–Aug. 25	12
Amber cane.	1½	June 25	Aug. 15–Sept. 15	12
Green sweet-corn stover.	1	June 10	Sept. 10–Oct. 15	5

TABLE XX

A SOILING SYSTEM WITHOUT ALFALFA OR CORN

Crop	Area, Acres	Approximate Date of Sowing	Approximate Date of Harvesting	Approximate Yield per Acre, Tons
Oats and Canadian field peas.	1	April 5	June 15–July 5	6
Oats and Canadian field peas.	1	April 20	July 1–20	5
Amber cane.	1	May 20	July 15–Aug. 20	12
Amber cane.	1	June 25	Aug. 15–Sept. 20	12
Amber cane.	1	July 5	Sept. 10–Oct. 15	12

The soiling systems outlined will, under average conditions, maintain a continuous supply of succulent green feed throughout the summer in a great many sections. They are exceedingly flexible and can be altered readily to suit individual conditions. There is no hard-and-fast rule as to what will be a successful soiling system, and the individual conditions must always be given due consideration.

CHAPTER XXI

WINTER MILK PRODUCTION

Early summer conditions, as already pointed out, are best suited for milk production; consequently, the aim in all-the-year-round dairying, which is the most profitable type, is to make winter conditions as nearly similar as possible to those of early summer. The ration of the dairy cow must be bulky and succulent, and the provision of abundance of succulence is one of the main problems of winter feeding. Attention to other considerations is also necessary.

Where silage is available, profitable winter feeding is easily possible, especially if a leguminous hay can also be obtained. These two constituents provide the necessary bulk, the silage renders the ration succulent, the legume provides a considerable amount of protein, and in addition these feeds can generally be depended on as a cheap source of digestible nutrients. Where roots are available at a reasonable cost the same end can be attained, but roots are not generally as available as silage in quantities sufficient to be of any great importance. Where silage and roots cannot be obtained dried beet pulp, when soaked before feeding, is a very valuable feed for rendering the ration succulent. It can also be fed with silage or roots. If succulent feeds or leguminous hays are not available, the winter feeding of dairy cattle becomes much more difficult and the very best results cannot be hoped for.

The grains that can be used profitably in winter feeding depend largely on the roughages that are available and the local cost of concentrates. The cereal grains are generally

satisfactory for the provision of energy-forming materials, and the choice between them will be determined largely by their cost. Where succulent feeds are available the choice of high protein concentrates will be determined largely by the cost of the digestible protein which they provide, but where succulence is scarce the action of the feeds on the digestive system of the animals is a factor of special importance. Cottonseed meal, because it is constipating, is not suitable for milk cows receiving no succulent feed, whereas wheat bran and old-process linseed oil meal, which are laxative, are especially valuable under such circumstances. Where leguminous hays are unavailable and dry roughages of a less nitrogenous character have to be fed, the amount of protein that must be provided by the grain ration is larger than would otherwise be the case.

It is impossible to give grain rations which would be satisfactory under all conditions, but a few general suggestions can be made which will serve as a guide in the formulating of concentrate rations for winter milk production. The rations given are satisfactory under the conditions mentioned, but they can be altered in accordance with local prices in order that the rations may be economical.

The grain mixtures suggested have been worked out to suit conditions arising from the availability or absence of certain roughages. The weight of the cow is assumed as 1000 pounds, and the production as 30 pounds of 3.5 per cent milk. This would indicate a daily ration of about 10 pounds of grain in addition to the roughages. Where silage is available a consumption of 30 pounds of silage and 10 pounds of hay per day will be about the amount demanded by a 1000-pound cow, while in the absence of silage about double the amount of hay will be required.

Only a few concentrates have been included as only a general type of grain ration is to be indicated. The corn-

and-cob meal can be replaced by cracked corn, hominy feed, rolled barley or similar feeds as required by special circumstances, and the proportions of corn and oats would also be controlled by local prices. The ground oats and wheat bran are interchangeable as they are of very similar value. So also are the oil meal and cottonseed meal under certain conditions. Other grains and by-products can be introduced as the market indicates.

TABLE XXI

GRAIN RATIONS FOR WINTER USE

Roughage	Corn Silage and Clover Hay			Corn Silage and Timothy Hay			Clover Hay			Timothy Hay		
Nutritive Ratio of Roughage	1 : 9			1 : 15			1 : 6			1 : 15		
Nutritive Ratio of Grain	1 : 6			1 : 5			1 : 6.5			1 : 4		
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Corn-and-cob meal	6	3	4	6	4	4	5	3	3	3	3	3
Ground oats	3	3	5	2	2	4	4	3	6	4	2	3
Wheat bran	....	3	....	..	2		...	3	....	....	2	1
Oil meal			1	1	1	2	1	1	1	3	3	3
Cotton-seed meal	1	1	...	1	1	...	....	....	....	....	....	....

In the case of the less valuable roughages limited variety in the grains is suggested as only a few concentrates can, as a rule, be used under such circumstances. Cottonseed meal, for example, is inadvisable when silage or some other succulent feed is not provided.

If succulent feeds and legume hays are both unavailable the winter feeding of dairy cattle is a difficult problem, and

the very best results cannot be obtained under such conditions. The grains that should be used in winter feeding depend largely on the nature of the roughage ration and the market prices of concentrates. Where succulent feeds are used, the demand for laxative feeds, such as bran and oil meal, is not so great as it is in the cases where only dry roughages are fed. The concentrate allowance should at all times, and especially in winter, consist of a variety of palatable constituents as this will give the most favorable results. The actual amount of grain fed is determined by the production of the cows.

The rations shown are suitable for use in general herd practice and have been worked out in such a way that the relative amounts of the various feeds needed to mix a batch of 1000 pounds of feed are indicated. It is generally most profitable in herd feeding to do this rather than mix up small amounts of feed.

With consistent methods of feeding, the milk production of dairy cows can be prevented from declining rapidly during the winter months, and the cows will be kept in such a condition that they will respond with increased production when turned to pasture in spring.

CHAPTER XXII

PREPARATION OF THE COW FOR PRODUCTION

EVERY dairy cow worthy of the name needs a rest between lactation periods—others take it. Long-continued copious milk production is a heavy tax on the energy of the cow, and if she is to work successfully through many lactation periods she must be periodically rested.

THE DRY COW

For best results the milk cow must have a rest of six to eight weeks between lactations. This will generally be a sufficient length of time in which to prepare her for the work of the following year. During this period the reserve stores of nutrients in her body are built up, her digestive system is cooled and rested, and in addition she is provided with the nutrients necessary for the growth of the fetus.

The amount of dry matter in the fetus is not large, but the major portion of it is formed during the last few weeks of pregnancy, and nutrients to be used in its formation must be provided. A cow that has been underfed and not rested will not, as a rule, produce a small, ill-nourished calf, but she will generally utilize the nutrients stored in her own body for the production of the fetus, and consequently will be in low condition and unable to produce milk to the best of her ability during the subsequent lactation period. The amount of nutrients needed for the building of the fetus is perhaps equivalent to the feed required for the production of a pound of milk daily throughout the lactation period.

If the cow is dry in early summer she will need very little feed in addition to what she can obtain from good pasture, unless she is in low condition, when she should be fattened with such feeds as cracked corn, ground oats and wheat bran.

When the dry period occurs in winter a fair allowance of silage should be given, along with a liberal amount of legume hay and a grain ration consisting of such feeds as ground oats, wheat bran and oil meal. During the dry period the ration should be laxative and should contain little of such heating feeds as corn, unless the cow is in low condition, while feeds such as cottonseed meal and timothy hay should be wholly avoided.

The main object in feeding the dry cow is to get her in good condition, and at the same time keep the ration laxative and cooling in nature and provide plenty of protein and ash for the building up of the fetus. Liberal feeding of the dry cow is good economy, as it will subsequently be repaid with increased milk production.

THE COW IMMEDIATELY BEFORE PARTURITION

When the pregnant cow approaches to within a few days of freshening, her grain ration should be considerably reduced, and it should be laxative in nature as this is a great aid to the preparation of the cow for freshening. A mixture of two parts of wheat bran and one part of old-process linseed-oil meal, by weight, is very valuable at this time on account of its laxative action. If this mixture does not give the desired effect, bran mashes can be fed, or a dose of 1 quart of raw linseed oil or 1 pound of Epsom salts can be administered. Too free use of purgatives is not to be advocated, as it may result in premature delivery of the calf. Freedom from milk fever and other post-parturient troubles is in a large measure due to the care with which the cow is handled and fed just previous to freshening. In the last day or two of pregnancy the

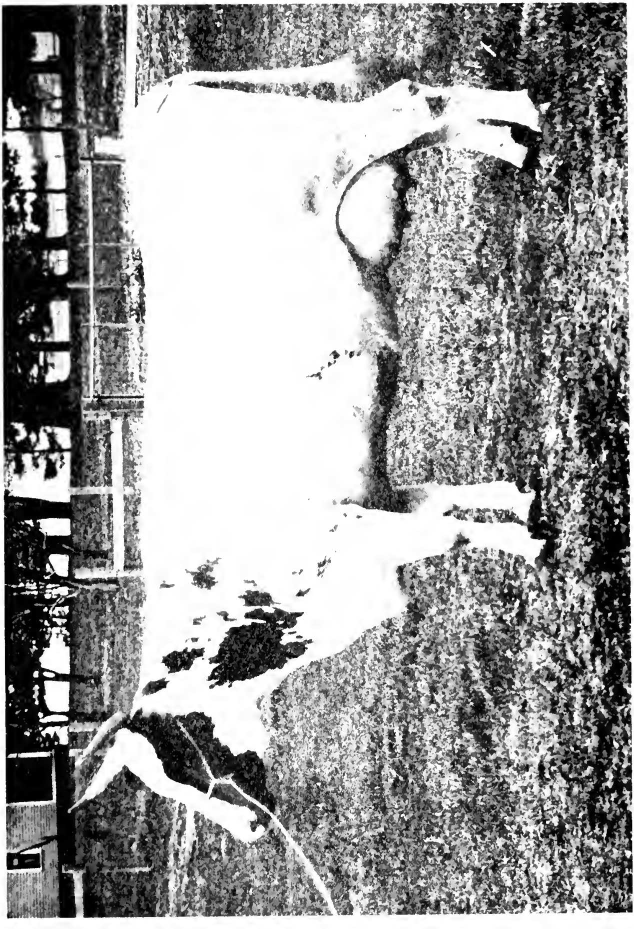

FIG. X.—Robinhood Cavalier Lass. Showing Condition Desired at the Beginning of a Lactation Period.

roughage ration should be limited, so that the digestive system may not be overdistended and interfere with labor. It is also well to replace the grain ration entirely with bran mashes.

THE COW IMMEDIATELY AFTER PARTURITION

Parturition is a severe strain on the cow; therefore while the digestive and other functions of the animal are coming back to normal the ration should be light. For a day or two after calving, feed the cow bran mashes in addition to alfalfa or clover hay and a limited amount of silage. During this period it is frequently advantageous to warm the drinking water slightly. A mixture of bran, ground oats and oil meal may be used to replace the bran in a day or two.

A period of thirty days is required to put a fattening steer on full feed, and at least this length of time should be given to bringing the dairy cow on to a full ration. The importance of this is easily recognized when it is remembered that the dairy cow is not only on full feed much longer than is the beef animal, but she is fed heavily during several successive periods. Consequently, great care should be exercised in raising the ration of the cow to a profitable maximum, as a too rapid rise in feed will result in indigestion, bloat and other digestive troubles.

Beginning with 4 or 5 pounds of grain per day on the fourth or fifth day after freshening, the grain should be increased at the rate of 1 pound on every third or fourth day until the maximum production of milk is reached. At this stage, that is, when the milk yield does not increase in response to additional grain, the allowance of concentrates should be slightly reduced, and it will generally be noted that the cow will then increase still further in production. In other words, the cow does her best work when her digestive system is not overloaded. The amount of grain the cow is being fed at this time is about what she should receive, as any less will

not give maximum production, and additional feed would be used for the production of body fat and so would not only be wasted so far as productive purposes are concerned but would ultimately lead to a decreased milk yield.

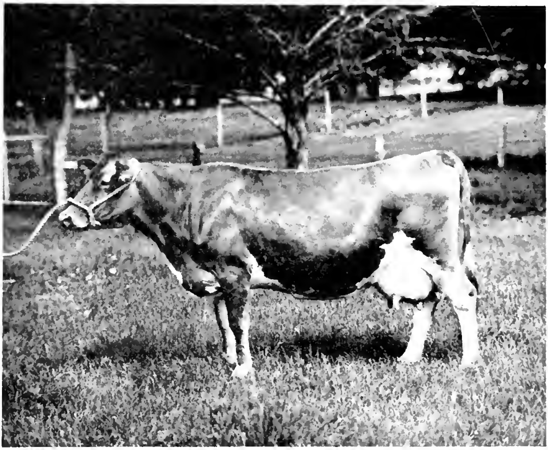

Fig. XI.—Miss of St. Louis II, in Good Working Condition when the Lactation is Well Started.

Starting the cow properly on her work for the year is of paramount importance, as the cow cannot do her best work unless she is properly fitted during the dry period and carefully tended both before and after freshening. No cow should be carelessly fed at this time if she is expected to produce well in the subsequent season.

CHAPTER XXIII

FEEDING FOR RECORDS

In general herd feeding economical production is the main object, and though this generally means large production, no attempt is made as a rule towards forcing the cows beyond their normal economic capacity. When official and semi-official tests are being made little, or generally no, attention is paid to economy of production. The aim is then to get the greatest possible production, and this necessitates even greater care in the preparation of the cow before her lactation commences than is usual in ordinary commercial practice. Throughout the test period every possible care has to be taken to have the cow consuming and producing to the height of her ability.

FITTING

The fitting of cows for record making is an interesting and important consideration, and much of the success of men as feeders of record-breaking cows must be attributed to their ability to prepare the cows for their work. Without successful preparation the best possible results cannot be obtained with animals on test.

Short-time Tests.—The making of official records begins a considerable time before the cows freshen. It is generally conceded that the condition of the cow at the time of freshening determines to a large extent her butter-fat production while on official test. The most common practice is to have the cow in high condition just before parturition; thus the

stores of body fat are drawn on later for the purpose of producing milk fat. However, a few men state that their best results have never been obtained with really fat cows; they believe that the practice of getting cows in extremely high condition with the idea of making large short-time records is injurious to the animals. Undoubtedly there is some truth in this assertion, as a dairy cow cannot be put in very high condition without allowing her to run dry for a considerable time, and in this there is a danger of ultimately shortening the lactation periods and injuring the breeding capacity of the cows.

The majority of breeders who conduct official tests believe, however, in having the cows in high condition at the time of freshening, though they disagree as to the methods to be pursued in attaining this end. A certain amount of conditioning is necessary to obtain the highest possible yield of milk from a cow when she freshens, but above a certain point the influence of this conditioning is on the fat content of the milk rather than on the milk yield.

The best method of fattening a cow previous to parturition is open to question, and the opinions of practical men differ widely on it. Definite proof has been obtained, however, that high condition in a cow at the time of freshening will result in an enhanced butter-fat percentage in the milk for a few weeks after freshening.

The majority of feeders believe that if a cow is to produce milk of a high butter-fat content following calving she must be fattened with feeds of high protein content. There is no definite proof that this is correct, but it is possible that the excess protein of the feed may keep the protoplasm of the cells in which the fat is stored in a highly active condition, so that, when freshening occurs, these cells will the more readily give up their stores of fat to be used for the production of butter fat.

In fleshing up cows for official test work, a considerable time is usually taken. The commonest period is two to three months, though some feeders take more and others less time. Those who use the shorter periods believe that when the body fat of the cow is laid on rapidly it is in a rather " soft " condition and will be readily liberated during the early days of the lactation.

The cow being fitted for test should have a legume hay and silage. Roots are also good on account of their appetizing qualities and the laxative action they possess; but if roots are given at this period they should be fed only in limited amounts as it is not good policy to distend to too great an extent the digestive organs of the pregnant animal. In the early part of the fitting period, corn and hominy are good feeds for the production of body fat, but in the later stages heating feeds should be avoided or used only in limited amounts. At this period old-process linseed-oil meal, wheat bran and ground oats are excellent concentrates. Throughout the fitting period such constipating feeds as cottonseed meal should be avoided.

Just before and after the time of parturition great care must be exercised in the feeding of cows that are to be put on test, as on this depends to a considerable extent the freedom of the cow from milk fever and other post-parturient troubles and her ability to withstand the heavy strain of forced milk and butter-fat production.

Long-time Tests.—The preparation of the cow for a yearly test is not as important as the preparation for short-time testing, since the short-time test is the more artificial. There is consequently not the same radical difference of opinion as to the methods which should be pursued in carrying out the fitting process for long-time tests. Before the cow is started on yearly test she should have a rest of two to three months or even longer. She should be put dry as early as possible, given a rest of a month or so without grain, and then be put

on a grain ration and put in as high condition as possible. The statements made regarding the feeds to be used for cows being fitted for short-time test hold true for those to be tested for a longer period.

Continued heavy milk production, such as is obtained when a cow is on yearly test, is a tremendous strain on the reserves of nutrients stored in the body of the cow and on her nervous energy; at the beginning of her record period she must, therefore, be in the best physical condition possible. A cow may decrease several hundred pounds in live weight while on yearly test and so she must be fitted to withstand this depletion of the stores of energy within her body.

FEEDING DURING RECORD PERIOD

The choice of the ration while the cow is on test deserves as great consideration as does the preparatory ration. While on test the cow must be kept in good healthy working condition and consuming feed to the maximum of her ability if largest production is to be obtained. The greatest danger perhaps is in overfeeding, as overfeeding will cause the cow to go off feed and decline in milk production, and under such conditions it is frequently difficult to bring the animal back to the high level of production which is necessary.

Short-time Tests.—As is the case in the preparation of cows for short-time tests, there is a considerable difference of opinion as to the best methods to be pursued in feeding the cow on official test. It is generally believed that plenty of succulence and a leguminous roughage are desirable at this time, while there is considerable variance in the views regarding the feeding of concentrates.

One group of feeders maintain that during the test period the grain allowance should be limited and should contain a relatively large amount of protein, as such a ration tends to cause the cow to utilize the reserve stores of fat in her body

for the formation of butter fat. Another belief, held by some, is that a large grain ration of high protein content should be fed in order to obtain the highest milk and butter-fat production during a short-time test. This view is modified by others who state that the grain ration must be large, but that it need not necessarily be of narrow nutritive ratio. These views are not easily coördinated, but it is possible to say much in favor of each of them. The success of feeding for short-time records, however, depends very largely on the skill of the feeder and his ability to fit the ration to the changing needs of the individual animals.

Beginning a few days after calving, the cow can be put on the test ration. Where roots are available, silage is seldom fed as the sole succulence; in fact, wherever possible, silage is usually fed in limited amounts, as too much silage decreases the appetite of the cow for roots and grain. Roots are one of the mainstays of those doing official testing work, and it is probably well to have the cows accustomed to them before freshening. Roots are appetizing, stimulate milk production and are laxative. The cows should be fed as many as they will consume, as a general rule. In some cases the daily consumption will run over 100 pounds. It is well to see that the roots do not cause scouring. Beets are the roots most commonly used, though others, such as carrots and rutabages are also satisfactory.

For the cow on test, a legume hay should be provided. Nothing can equal good quality alfalfa or clover hay under such conditions, as they provide more nutrients than do other hays, as well as rendering the ration bulky. The cow on test needs bulk in her ration, but the provision of digestible nutrients must not be sacrificed.

The grain ration is started gradually, and the cow never overcrowded as this results in decreased appetite and lowered production. For energy-producing feeds, cracked corn, corn-

and-cob meal, or hominy feed are quite satisfactory, and oil meal is excellent for bringing up the protein content of the ration. Some feeders use gluten feed for this purpose, but if fed liberally it tends in many cases to put the cows off feed. Ground oats and bran are also excellent, especially as they add bulk to the grain ration and help to keep the cow in good working condition.

Long-time Tests.—In feeding for yearly records the main object is to keep the cow consuming to the maximum of her capacity throughout the year. This can be done only by skillful management, and throwing the cow off feed at any time may be sufficient to spoil her chances of making a creditable record.

Here, also, roots, silage and a legume hay generally form the basis of the ration, and in summer some good succulent green feed should be provided. The feeding of the succulent feeds should be liberal, as they keep the cows in good working order and stimulate the milk flow to a maximum.

A heavy grain ration is essential, but at least thirty days should be allowed to get the cow on full feed, as overcrowding at the start of the record is apt to lead to loss of appetite, digestive troubles and sometimes congestion of the udder. The grain ration must contain plenty of the energy-providing feeds, but a liberal supply of protein is also essential. The cow will generally lose rapidly in weight for a month or two at the beginning of the period, but, after this, loss in weight should be prevented as far as possible as it ultimately saps the vitality of the cow and decreases her production. On the other hand the cow must not be kept too fat, as this also leads to lessened production of milk and butter fat as a general rule.

FEEDING FOR A HIGH FAT PERCENTAGE

It is the belief of many that the percentage of fat in milk can be influenced by feeding and other practices. This is in

the main incorrect. It has been shown that there is no drug which directly influences the fat content of milk. Certain drugs, which are reported to do this, simply cause some derangement in the normal processes within the body of the cow. Such derangements may lead to a change in the butter-fat percentage present in the milk, but this change is downward as often as upward, and ultimately there is no benefit to be obtained by such doubtful practices. In fact they are dangerous, as the use of drugs by amateurs for this illicit purpose has sometimes resulted in the death of valuable animals.

It is true, however, that certain feeds will very frequently lead to a temporary increase in the fat percentage of milk. It must be remembered, however, that this increase is brought about by a derangement of the digestive and other processes of the animal, and sometimes leads to a decrease rather than an increase in butter-fat yield. The increase in fat percentage is most generally obtained when the feeds of this character are introduced into the ration suddenly and in fairly liberal amounts. Their effect on the fat content of the milk lasts but a few days and in many cases it is accompanied by a loss of appetite and other derangements in the cow. Feeds which are frequently used for this purpose are cottonseed meal, flaxseed meal, coconut meal and peanut meal.

CHAPTER XXIV

CALF-RAISING

The future of a dairy herd always depends on the care given to the rearing of the heifer calves that ultimately must take their place as producing individuals, and from the first their feeding must receive attention. It is possible to purchase heifers of about producing age, and though this policy may at times be justified, it is not the best method of building up a really productive herd. If the dairy farm is to be a constructive undertaking, the owner must, as far as possible, breed and rear the animals which will produce his marketable products. If the heifers that are added to the milking herd are to do their best work, it is essential that their early feeding and care be such as to induce maximum development, as underfed individuals can never produce to the maximum of their natural ability even if well fed during their period of usefulness. This is a fundamental fact which must never be neglected if the most economical results are to be obtained.

EARLY TREATMENT

The practice of allowing calves to remain with their dams for the first two or three days after birth is to be recommended. This permits the calf to nurse its dam and thus secure the colostrum, or first milk, which, being high in albumen and ash, is so essential for the young animal. The colostrum is laxative in action, assists in the expulsion of the meconium, or fecal matter occurring in the intestine of the newborn, and stimulates the activities of the digestive tract of the calf. This practice

also permits the calf to feed as often as desired, while the nursing of the calf is beneficial in relieving a congested or inflamed udder.

Where it is not possible to allow the calf to remain with the dam longer than a few hours, the colostrum should be milked and given warm to the calf in small quantities and at short

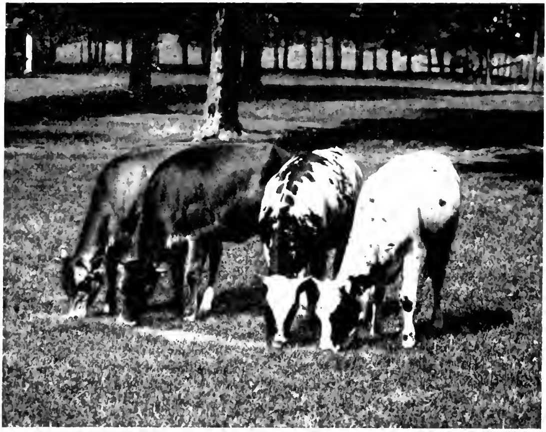

FIG. XII.—The Foundation of Production.

intervals. Whenever possible, however, the calf should be allowed to suck for two or three days.

TEACHING TO DRINK

One of the decisive periods in the life of the calf is when he is being taught to drink. If the calf is taken from his dam soon after birth, he will as a rule learn rapidly to drink; but as it is not generally advisable to practice such early weaning, difficulty is sometimes experienced later in getting him to

take to the bucket. When the calf is to receive his first lesson he must be hungry, as he is then a more apt pupil. Only a little warm milk in a clean bucket should be offered, and very often a few minutes' coaxing will be all that is required to get the calf to drinking. Even if he drinks well, however, only a little milk should be given at each meal, so that the calf will be hungry and ready to drink at the next feed.

When the calf is backward at drinking, a good method is to get him in a corner so that he cannot back away, and put one or two fingers in his mouth. He will suck the fingers, and while he is doing this his head should be lowered gradually until the hand is in the milk. The calf will then suck up some of the milk. When he has done this for a little time, the fingers are gradually removed and, as a rule, he will, after a few trials, learn to drink alone.

If neither of these methods is successful, the feeder should back the calf up in a corner, get the calf's neck between his legs, put the head down into the bucket and hold it there in the effort to force the calf to drink.

The main aids to success in teaching a calf to drink, in addition to keeping the calf hungry and ready for meals, are patience, perseverance and practice.

FUNDAMENTAL PRINCIPLES IN HAND FEEDING

A few fundamentals are largely responsible for the degree of success with which the feeding of young calves is carried out. The milk, whether whole or separated, should be fed as soon after milking as possible, so that it will still be warm. The buckets used must always be clean, which requires washing and rinsing out after each feed, scalding daily, and airing in a sunlit place. The buckets should not be thrown down unwashed in a corner of the calf pen. Cleanliness is an essential in the calf's feed bucket, as it is in the milk pail.

The feeding should be regular in time and amounts; feeding at irregular intervals, or in undetermined or irregular quantities always tends to produce digestive troubles and unthrifty calves. The feeding should always be guided by the milk scales or quart measure, and increases in the ration should be gradual. The calf should be kept hungry rather than overfed, as overfeeding causes digestive disturbances, while calves that are ready for their meals are, as a rule, thrifty.

WHOLE-MILK PERIOD

When the calf is two or three days old he can be taken away from the dam and fed fresh, warm, whole milk in quantities that will be determined by his size and vigor.

The average birth weights of the calves of the various dairy breeds dropped on Iowa State College Dairy Farm from 1908 to 1919 show that there is quite a wide variation in this respect between the breeds. The individual variations within the breeds are even larger. This shows that quite a wide variation in the feed requirements of young calves will be manifest.

TABLE XXII

Average Birth Weights of Calves

Sex	Male, Pounds	Female, Pounds	Average, Pounds
Ayrshire	67	66	66
Guernsey	64	61	63
Holstein	97	90	94
Jersey	55	52	54

Calves just removed from their dams will, as a rule, require 6 to 12 pounds of whole milk per day. The feeding should be done three times daily until the calf is about three weeks old,

when the number of feeds can be reduced to two per day, and the substitution of skim milk for whole milk may begin.

SKIM-MILK PERIOD

This substitution must take place slowly and may be completed when the calf is about six weeks old. At this age the amount of skim milk required will vary from 12 to 16 pounds per day. When on full feed, 16 to 18 pounds of skim milk daily will, as a rule, be sufficient for a calf.

While skim-milk feeding should continue until the calf is seven to eight months old, for the very best results, yet many calves are successfully reared though entirely weaned when four months of age. The additional allowance of skim milk, however, keeps the calf in thrifty condition, sustains rapid growth and promotes true economy in the production and development of high-class dairy cattle.

USE OF OTHER DAIRY BY-PRODUCTS

The great majority of dairy calves are reared on skim milk, but in some sections skim milk is scarce and other available milk by-products can be successfully used in growing out the young stock.

Buttermilk.—The value of buttermilk for calf-feeding is very similar to that of skim milk, as it contains about the same amount of nutrients. Its acid reaction is not at all detrimental, provided the calves are allowed to become accustomed to it gradually. Care should be taken that the buttermilk is fed while fresh and not allowed to vary widely in acidity.

Whey.—In cheese-making districts whey is used to some extent for calf-feeding. Its feeding value is about half that of skim milk. In feeding whey it should be remembered that the supplements fed with it must be of high protein content as it is low in protein and high in carbohydrates, while skim

milk has a relatively high content of protein. It cannot be fed in as large quantities as can skim milk, as a liberal allowance of whey and the necessary supplements will cause the calves to become paunchy. The amount of whey should be limited and the grain ration increased.

Dried Products.—In market milk districts where skim milk is scarce, skim milk and buttermilk powders are sometimes used for calf-feeding. They are mixed with water and fed in the same way as skim milk, and are useful feeds when not too high-priced.

MILK SUPPLEMENTS AND SUBSTITUTES

A milk supplement is usually a concentrate allowance fed along with skim milk to replace the butter fat of the milk, while a substitute is fed in place of the milk when the latter is not obtainable.

In many market milk sections, whole milk and even skim milk are scarce and expensive for calf-feeding purposes, and though the entire elimination of milk for calf-feeding cannot be recommended, yet at times it is necessary that milk be replaced to a certain extent. Consequently, there are on the market a large number of milk supplements and substitutes for calf-feeding. Some of these are good, but the prices asked for all of them are generally too high to give economical returns.

When skim milk is available no supplement other than a good grain ration is needed, but where even skim milk is scarce some substitute must be found. Where milk substitutes have to be used it is probably best to defer using them until the calves are six or eight weeks old and then substitute them gradually in a manner similar to that used in replacing whole milk with skim milk.

A good milk substitute recommended by the Indiana Agricultural Experiment Station consists of equal parts of old-

process linseed-oil meal, hominy feed, Red Dog flour and dried blood. One pound of this mixture in 8 pounds of water will be sufficient for a calf six weeks old, and the allowance is increased as the calf grows. Such a mixture is efficient and economical, and will give good financial returns. The use of such a home-made mixture is to be preferred to the purchase of high-priced proprietary milk substitutes.

MISCELLANEOUS FEEDS

Milk is the best feed for the young calf, but it would be extremely expensive to raise calves solely on whole milk or even on skim milk. In addition to this, the digestive system of the calf develops rapidly; this is particularly true of the rumen, which is especially adapted for the handling of rough, bulky feeds. Consequently, for maximum and most economical growth and development, feeds other than dairy products must be furnished for the young growing calf. The importance of those additional feeds is too frequently overlooked.

Grain.—Young calves very readily begin to consume grain, and it should be provided for them about the time the substitution of skim milk for whole milk is started, or at three weeks of age. A practical method is to feed the grain just after the calves have had their milk, as this tends to prevent them from sucking each other. A good concentrate allowance provides an abundance of the muscle- and bone-building nutrients, protein and ash, and also contains a liberal amount of fats and carbohydrates to replace the fat abstracted from the milk. Corn, oats, bran and old-process oil meal are excellent grains for calves, and several combinations of these feeds can be used with satisfactory results. The proportions of the various ingredients used will depend on feed prices, the requirements of the calves and other individual factors. In some cases corn or oats is used as the sole grain for calves, but this practice cannot be advised, as corn does not provide sufficient protein

or ash and oats contains too large a proportion of fibrous material to allow it to be used satisfactorily as the sole concentrate in the ration of young animals. It is easy to make for calves suitable grain mixtures which will consist largely of home-grown materials. A few mixtures of this type are outlined and can be altered to suit conditions.

TABLE XXIII

Grain Mixtures for Calves

Grain	Pounds	Pounds	Pounds	Pounds
Corn	5	3	5	5
Wheat bran	2	3	4	.....
Oats	2	3	....	4
Oil meal	1	1	1	1

The grinding of grain for calves has been a disputed question, though the majority opinion has been that young calves should receive unground grains. This belief is substantiated by evidence obtained at the Iowa Station in a self-feeder trial with young dairy calves.

Three calves, averaging forty-five days of age and being fed milk and allowed all the alfalfa hay they would consume, were given access to a number of concentrates in a self-feeder. The feed consumption of the calves was determined for two periods of thirty days each.

During the first period, when a large amount of whole milk and little skim milk was fed, the calves used considerable quantities of protein supplement, especially oil meal. They ate no hominy and practically no corn, but a considerable amount of oats, and this almost entirely in the form of the whole grain.

In the second period the proportion of skim milk was increased, and the calves varied their grain ration to comply

with conditions. Their consumption of whole oats was larger, while the amount of whole corn used increased enormously and the ground grains and hominy were avoided. The total consumption of whole grain was 237 pounds while only 1.5 pounds of the ground material was used. This indubitably shows that young calves prefer whole grain and will thrive best when provided with such materials.

TABLE XXIV

GRAIN CONSUMPTION BY SELF-FED CALVES

Period	I.	II.
	Pounds	Pounds
Whole milk	864	678
Skim Milk	168	678
Shelled corn	1.3	108.6
Cracked corn	.0	.3
Whole oats	58.7	68.4
Ground oats	.4	.5
Hominy feed	.0	.3
Gluten feed	15.3	1.9
Wheat bran	13.3	17.3
Oil meal	62.7	75.0
Alfalfa hay	32.7	91.9
Nutritive Ratio	1 : 3.4	1 : 3.5

The consumption of linseed-oil meal and bran increased in the second period, while that of gluten feed decreased. This decrease was perhaps due to the fact that the heavy consumption of shelled corn at this time provided the calves with all the corn protein they required.

It is of interest to note that during the two periods the calves kept the nutritive ratio of their ration about uniform—the nutritive ratio was 1 : 3.4 in the first and 1 : 3.5 in the

second period—and that they did not become too fat as might have been expected from an unlimited allowance of grain.

In practical feeding, grain should not be allowed to remain before the calves continuously, as it becomes stale under such conditions. They should have just what they can clean up in a short time—not more than half a pound per head daily until they are eight to ten weeks of age. From then until weaning time, 1 pound per day will usually be sufficient under average conditions.

Hay.—The importance of roughage for young calves is paramount, as without its presence the proper development of the digestive tract is impossible. It has been demonstrated at Iowa State College that a ration devoid of roughage, even though it contains an abundance of nutrients, will not lead to the normal development of the calf.

TABLE XXV

EXCESS OF NUTRIENTS SUPPLIED TO CALVES ON A WHOLE-MILK RATION

Age, Days	Total Dry Matter, Pounds	Digestible Crude Protein, Pounds	Total Digestible Nutrients, Pounds
1–30	8	3	20
31–60	−11	1	13
61–90	−43	1	12
91–120	−74	0	1
121–150	−86	−2	1

Throughout the experiment, a summary of which is tabulated, the calves were being supplied with more total digestive nutrients, in the form of whole milk, than were necessary for maintenance and growth, while digestible protein was also supplied in abundance until near the end of the experiment. The surplus of nutrients in the ration decreased with the

advance of the experiment, on account of the fact that the calves were unable to handle more milk.

Though digestible nutrients were being supplied in abundance there was a deficiency of dry matter in the ration during all periods except the first; as a consequence the calves were unable to utilize the nutrients in the milk and failed to develop normally.

TABLE XXVI

INCREASE IN LIVE WEIGHT AND BODY MEASUREMENTS OF CALVES

Ration	Weight, Per Cent	Height, Per Cent	Depth, Per Cent	Width, Per Cent
Milk alone	104	19	16	19
Normal	345	35	57	75

The calves fed milk alone did not make the live-weight gains which would be expected from calves fed normally, and their body dimensions also increased very slowly. On postmortem examination the experimental animals were found to be lacking proper bone development, and the digestive tract, especially the rumen, was poorly developed. This work showed not only that abundance of digestible nutrients must be supplied, but also that some bulky materials are needed to allow the animal to utilize feed efficiently and develop normally.

Roughage is essential for the young calf, and the feeding of hay should begin at about the same time as the feeding of grain. From that time on, hay should be kept before the calves.

Alsike clover, being fine-stemmed and leafy, is the best hay for young calves. It provides plenty of bulk, is not too coarse, and contains a liberal amount of nutrients. Red-clover hay and mixed hay are also satisfactory and are widely used.

Alfalfa hay is not so satisfactory as good clover, as its high content of protein and ash renders it too laxative and gives it a diuretic action. It is used, however, and gives good results. Timothy hay and the straws should not be fed to calves, as they are too fibrous, are difficult to digest and contain only small amounts of useful nutrients.

Silage.—Silage should not be fed to young calves, and if fed at all to those under weaning age it should be in very limited quantities. Even then care must be taken that only the fine particles, excluding the cobs and stalks, are fed, and that the material is taken directly from the silo and not allowed to lie in the manger until spoiled. If these points are not given due attention digestive derangements, especially scours, will result.

Roots.—Where roots are available they can be used to advantage in calf-feeding. Their palatable, succulent nature renders them very valuable and they aid in keeping the digestive system of the calf in good working order. They should always be cut and never fed in quantities larger than the calves will clean up in a short time.

Pasture.—Fall and winter calves that have been properly tended can advantageously be allowed access to pasture in late spring or early summer, but spring calves should not be put to pasture under three months of age, unless under exceptionally favorable conditions. Even when they can be turned out it should be for but a few hours during the cooler time of the day. Heat and flies are the two great enemies of young calves and they can, as a rule, be more easily guarded against in the barn. For older calves, however, pasture is exceptionally good as it provides abundance of palatable, nutritious, succulent feed, and in addition the calves secure plenty of fresh air and exercise. The calf pasture need not be large, but it should be provided with fresh water and plenty of shade.

Water.—Calves, even when being fed milk, require plenty of water, and they should have an opportunity, at least once a day, of getting all the fresh water they desire. It has been found at the Iowa Station that, even in winter, calves will drink 4 to 8 pounds of water per head daily, while at the Kansas Experiment Station calves receiving skim milk consumed 10 pounds of water per head per day during summer. Stagnant water in the barnyard or in ponds to which the calves have access may induce serious intestinal disturbances or even cause general poisonous effects, and so must be avoided.

Salt.—Salt should be provided at free will, as soon as the calves are old enough to consume hay and grain. The growing calf requires salt, and proper utilization of feed and normal development cannot be expected in its absence.

Condiments.—The calf needs large amounts of ash, especially lime and phosphorus, for the building of bone. Consequently, calves are sometimes given access to ground rock phosphate or chalk. Such a practice is probably advisable where the ration is deficient in the essential ash constituents, but as a general rule it is not necessary.

Dried blood appears to have a beneficial effect in the checking of scours. Some feeders mix dried blood with the grain ration or give the calves access to a mixture of dried blood and salt. Powdered charcoal also tends to prevent digestive disturbances and is sometimes used in a similar way.

CHAPTER XXV

FEEDING DRY STOCK

THE greatest amount of feed on the dairy farm is consumed by the milking herd, and the most attention is generally given to the feeding of the producing individuals. This is probably due largely to the fact that the immediate results of good feeding can be noticed in increased production. The feeding of the heifers and herd bulls, which should also be recognized as of importance, is too often given a secondary place.

THE GROWING HEIFER

Many dairy calves are well treated and kept in good condition until the time of weaning, but are then neglected. This is poor economy, as the heifers must be kept in good, thrifty, growing condition right up to the time of freshening if they are to do good work when they join the producing herd. When the age of weaning is reached, the skim milk should not be withdrawn from the calves suddenly; three or four days to a week should be given for this operation, as sudden changes in feeding tend to throw the calf off feed and arrest its development to a certain degree.

If fall calves have been properly fed and managed during the winter it is not difficult to carry them through their first summer. After weaning they should be on pasture as much as possible and in addition receive a little grain. The grain rations can be very similar to those recommended for young

calves, but the corn and oats should be increased at the expense of the bran and oil meal.

In the following winter, when the heifers are about a year old, the feeding should be liberal so as to keep the animals in good growing condition, as the main object is to produce animals with a good constitution and adequate capacity. The feed should be bulky and at the same time should supply plenty of protein and ash, as the protein and ash aid in the building of muscle and bone, and bulky feeds distend and develop the digestive organs. Alfalfa and clover hays are the best dry roughages to feed to dairy heifers at this stage of development, and silage is useful in limited amounts.

Where silage is available, 15 to 20 pounds per day may be fed to dairy heifers during the winter. With 7 or 8 pounds of a legume hay and 2 to 3 pounds of grain, this makes an excellent ration. Where silage is not available, the allowance of hay can be doubled and an extra pound or two of grain added. The grain ration can be very similar to that used in the earlier stages of development, but a greater predominance of the carbohydrate feeds, such as corn and oats, is to be preferred. Though whole grains are to be recommended for young calves, it is probable that ground grain is better for older heifers.

During the next summer, that is, when they are about eighteen months old, the heifers will need little but pasture until fall. After that the treatment may be similar to that of the previous season up to the time when it is necessary to prepare them for their first freshening.

Spring and summer calves will be on milk during the greater part of their first summer and will not have access to much pasture. At the beginning of winter they are generally weaned and during that season they will be treated in much the same way as fall heifers, but the amount of silage they receive will be limited. From the time they are a year old the treatment for spring heifers is the same as for fall calves.

BULLS

The herd sire is the most important animal on the dairy farm, but in spite of this he is frequently given less attention than any of the other animals. The degree of development and the vitality of the bull are to a considerable extent influenced by feeding. A bull that is not fed liberally cannot

FIG. XIII. Iowana Mercedes Homestead in Working Condition.

be expected to develop as he should, while improper feeding frequently leads to impotence.

During the first six months of life the treatment for young bulls is the same as for heifer calves. At six months of age, however, and even earlier in the case of precocious individuals, the animals of different sexes must be separated. From this time until maturity the bulls will require relatively more grain than do the heifers. During summer young bulls do well on pasture and grain, while in the winter a legume hay and grain should form the bulk of their ration.

With older bulls, where the main object is to keep them in good breeding condition, the ration should consist largely of alfalfa or clover hay and grain, with only a limited amount of silage. Good results cannot be obtained by feeding large quantities of silage to the dairy bull, as this causes over-distention of the middle and tends to render the bull paunchy, sluggish and slow in breeding. Not more than 10 to 15 pounds per day of silage should be fed. The grain ration must contain a fair amount of protein; a mixture of cracked corn, ground oats, wheat bran and oil meal is excellent. The proportions of the various concentrates to be used and the amount to be fed will be determined by the individual requirements of the bull. Where older bulls have access to some pasture, they should not be made to depend on the pasture entirely but, as a general rule, should have some grain.

The young bull should be kept growing and be provided with plenty of protein and ash. The bull that is in service must be kept in good, thrifty condition, as underfeeding will cause the bull to fail during a season of heavy service, and overfeeding or improper feeding will cause the bull to become fat, paunchy, sluggish and unfit for breeding purposes.

CHAPTER XXVI

FEEDING FOR SHOW AND SALE

A GOOD show-ring record or a creditable average price at a public sale is one of the best forms of advertising that the breeder of pure-bred live stock can obtain. For success in either a show or a sale ring, good cattle are necessary, and the man showing them must know his business. In addition, however, the feeding and management of the cattle have a marked influence on the final results. Many amateur showmen look upon the brush and blanket as the main essentials in the fitting of cattle, forgetting the great importance of the feed-bin.

In showing cattle it is necessary to have them in the proper condition of fleshing, though this is not as important with dairy cattle as it is in the case of beef cattle. It is a well-known fact, however, that the condition of an animal may have a considerable influence on its final ranking in the show ring. The condition in which an animal may be shown varies with the breed; Jerseys and Guernseys are shown relatively thin, while Holsteins and Ayrshires must be fairly smooth in fleshing. Animals that are too thin present a poor, unprepossessing appearance, while those that are in too high condition may appear coarse and lacking in refinement, and may be discriminated against as lacking the indications of quality in a dairy animal.

The degree of flesh in which an animal should be shown will very often depend on individual characteristics as certain faults are emphasized or diminished by the condition of the

animal. For example, a cow that is coarse over the withers may often be improved considerably in appearance by a reduction in the amount of flesh she carries.

In dairy cattle a deep, wide, roomy barrel is desired, as this indicates capacity for handling feed. This is largely controlled by feeding, and everything should be done to develop capacity in the animals to be shown. Overdistention of the middle should be avoided, as this imparts an ungainly and frequently an unthrifty appearance.

The quality of the skin and hair in cattle is very largely affected by feeding, as well as by some managerial practices. The hide of the dairy animal should be soft, pliable, loose and relatively thin, and covered with a fine, smooth coat. All tendency towards harshness should be avoided; the feeding will control this to a considerable degree.

EARLY PREPARATION

The time of beginning the early preparation of the animal for showing will depend largely on its condition, but plenty of time should be given and, as a rule, at least two to three months will be required. The roughage ration should consist of palatable constituents with as much succulence as possible. A good legume hay with silage or roots forms the best possible basis. Dried beet pulp, fed in a soaked condition, is also very valuable as a substitute for silage or roots, where these are not available, and it is also a good plan to use it in small amounts continuously or to substitute it at intervals for the silage or roots, so as to give added variety to the ration. Green succulent feeds, such as green alfalfa, amber cane and sweet-corn fodder, are also excellent. The main object in feeding these roughages is to keep the animal in good physical condition, as well as to provide nutrients, and to develop plenty of capacity in the animal.

The grain ration should consist of palatable concentrates

suited to the tastes of the animals and fitted for the laying on of fat and the keeping of the digestive system in good working order. Corn, oats and bran are very valuable for this purpose, and hominy feed is also good. Old-process linseed-oil meal is perhaps the most valuable concentrate there is for fitting a herd, as it not only fattens, but puts a bloom and finish to the coat that can be obtained with no other feed; it also renders the skin soft and pliable and increases the oily secretions so much desired in some breeds. It is best, however, to feed oil meal during the last four or five weeks only or, if before that, in limited quantities, as after prolonged feeding of linseed meal an animal may go " stale " and the hide and coat may not have the condition and appearance desired.

In the feeding of calves for show or sale it is necessary that they have all the milk they can handle, and this should be supplemented with good, bright clover hay and a grain ration of corn or hominy, oats, bran and oil meal. As is the case with older cattle, the oil meal should be limited in amount until near the end of the fitting period.

FINAL FITTING

The shipping of the cattle to show renders some changes in feeding necessary. While the animals are on the road, silage is unavailable, so before they leave it is well to have them accustomed to a succulent ration of roots alone or beet pulp. Roots can generally be obtained at the main shows, and beet pulp is convenient as it can be used when the cattle are in transit. Except for these preparations and the liberal feeding of oil meal, the feeding will be little changed, though the danger of overfeeding must be guarded against. An animal can be overfed a month or two before the show and bad results may be remedied in time, but overfeeding a day or two before showing may be fatal to success.

The cattle must be shown with a good fill to indicate their

capacity for handling feed. It is a common practice to withhold water from the animals for some time before showing and salt them well, then to get them to eat liberally and then fill with water. This process may take a considerable time on occasions, and it is a common practice to get the animal well filled up and give the last drink just before showing. Some animals, however, have to get all the fill at once, as they will not drink a second time. Individual characteristics have to be studied in this. There are certain points to be guarded against at the time of filling the animals, as overfilling may tend to cause the skin to become tight. It may also induce an ungainly gait and where carried to excess will chill the animal and spoil the chances in the ring.

Fitting cattle for show or sale is an art, and only by constant attention to feeding and management and interest in the peculiarities of the individual animals can success be obtained, even though the herd be individually excellent.

CHAPTER XXVII

WATER AND SALT

THE concentrates and roughages given to dairy cattle are generally considered high-priced and so are given plenty of attention; and there is a tendency on the part of many to neglect two very important constituents of the ration, water and salt. They are ubiquitous and cheap, and consequently their importance is minimized. Water and salt are just as important as the other constituents of the ration; in fact they are absolutely essential, and so must not be neglected.

WATER

Water is absolutely essential for the maintenance of life and for the production of new body tissue, and its importance for the milk-producing cow can easily be appreciated from the fact that 87 per cent of milk is water. Water must be provided in abundance for all classes of live stock and they should have all they want.

It has already been demonstrated that water is consumed in considerable amounts even by milk-fed calves, and it has been found at the Iowa Agricultural Experiment Station that milk-producing cows will consume from 3 to 5 pounds of water for each pound of milk produced. Heavy producing cows consume large amounts of feed daily, but the weight of the feed eaten is frequently small when compared with the water consumption.

The two main essentials in the water supply are abundance

and purity. A dependable supply must be obtained if all of the animals on the farm are to receive as much as they need, and purity is essential as a safeguard for their health. For these reasons deep-well water is the best. Surface water should be avoided, as it is generally very variable as a source of supply and is subject to contamination which may render it dangerous.

During the summer, water should be provided for the cows when at pasture, and should be in a tank if possible. If a stream is the source of supply, it should be so protected that the cows cannot stand in it and convert it into a puddle. Water should also be available where the cows can obtain it on their way between the pasture and the barn as they generally tend to consume considerable amounts of it at such times.

In winter the cows should not be turned into wind-swept lots and forced to drink ice-cold water on which the surface ice has just been broken. Water should be provided in the exercise lots, but tank heaters should be provided to keep the temperature of the water well above freezing. Means for watering the cows in the barn should be provided if possible; for this purpose two methods are in common use—individual drinking cups or a continuous cement manger with a faucet at one end and a drain at the other.

The individual drinking cups keep water before the cows at all times and eliminate the labor of watering, but they have their drawbacks. They are expensive to install and sometimes difficult to keep in good repair. In some cases the bowls tend to collect dirt, and so, instead of providing the cow with fresh water, they continually contaminate her supply. Again, cows will occasionally force the valve of the cup open so that it will not close, and when this happens during the night a flooded barn is the result. In the case of cows being kept in pens and forced for records, and perhaps in the case of

calves, the individual cups have some advantages, but for the general milking herd individual drinking cups are not thoroughly practical, especially as freezing is apt to occur where exposed pipes supply the cups.

The continuous cement manger presents none of the disadvantages of the individual watering cups, and by its use the cows can be watered two or three times daily with very little difficulty. The use of the manger as a watering trough also acts as an added incentive to keeping it sweet and clean. No matter which system of watering is used the cows should have the opportunity of getting all the water they desire.

SALT

Of the utmost importance is the supply of salt, as salt is necessary for the proper functioning of the body and for milk production. It is necessary for all classes of dairy stock, though their requirements vary widely. The amount of salt consumed daily is governed to a considerable extent by the live weight of the animal, by the amount of milk produced and by the nature of the ration. In addition the individual variations in requirements for salt are very great, and though it is impossible to predetermine the salt consumption of any cow, the average amount required is perhaps about 1 ounce per head per day.

Some cows take salt daily and are fairly regular in their consumption of it, while others may go for several days or even a few weeks without taking any salt, and then take a large supply and abstain from it for another long period.

There are three main methods of supplying salt to milk-producing cows—namely, mixing it with the feed, providing it at stated intervals, and giving it to them at free will. Mixing it with the feed is not satisfactory as some cows will get more salt than they require, while others will not get enough. The same holds true practically for salting at intervals.

The best method is to keep salt in front of them at all times, as then each cow gets what she wants and when she wants it. While the cows are on pasture, a salt box should be kept in the pasture and in winter a box of salt should be kept in the exercise lot.

There are on the market salt rolls and other preparations to be kept affixed to the mangers. These are not practical as the cows lick them unevenly and the rolls break and fall off. Rock, compressed and crushed salt are all used for dairy cattle, and there is much difference of opinion as to which should be used; in practice there is very little difference between them as long as the cows obtain all they desire. Bulls and young stock should also receive all the salt they want.

CHAPTER XXVIII

FEEDING METHODS

THE supplying of the cow with the requisite amount of feed is not the only feeding problem with which the dairy farmer is confronted. The ration should not only be of the proper character, but should be fed in the best possible manner. The influence of the method of feeding on the production of the cow and on the general economy of the dairy operations must both be considered.

ORDER OF FEEDING

Much more important than the time or order of feeding is the regularity with which it is done. It does not do to feed a cow just when the feeder feels inclined: she should have regular meal hours. Many find it advisable to feed the grain before the roughages as the cow eats her grain rapidly and then takes her time with the coarser feeds. A very good method is to put the grain on top of the silage; this not only allows her to have her grain first but also generally causes her to consume some silage with it and helps to lighten up the grain and prevent digestive troubles. The grain is sometimes fed at milking time, and the cows are perhaps a little more contented while being milked if they then have grain before them.

Hays which may cause dust in the barn, and feeds, such as silage and rutabagas, which tend to impart taints to the milk, should be fed after milking and not before. A good method is

to feed the hay two or three times per day and the silage and grain twice. This allows the cow to make better use of her feed than she would do if it were fed less frequently and in larger quantities. Grain, if fed only once daily, in a large quantity, may also at times tend to cause digestive disturbances.

FEEDING OF ROUGHAGES

The most convenient way of feeding silage is to use a wagon, which can be filled at the silo and pushed around in front of the cows, and feed the silage with a scoop. The installation of overhead tracks greatly facilitates this process. If a few scoopfuls of silage are weighed occasionally, the silage can be fed with a fair degree of accuracy and with the knowledge that each cow is receiving the required amount.

Baled hay is convenient for feeding purposes, but where home-grown hay is used the hay chutes should be so placed as to allow the feeding to be done with the minimum amount of trouble and without causing too much dust in the barn. The allowance of hay, like the allowance of silage, should be weighed occasionally.

FEEDING OF CONCENTRATES

The mixtures and quantities of grain to be fed should be determined, as has already been advised, for each cow individually wherever possible. As a general rule, however, this is not convenient as it involves a large amount of labor. A general mixture, which is found to be economical, can be made up and weighed out to each cow. A number of methods of feeding the grain ration are in general use, and a few of these may be mentioned.

1. A cabinet of drawers, each of which is large enough to hold the grain allowance for a cow for one day, is provided.

Each day the grain allowance for each cow is weighed up and placed in the appropriate drawer, and when feeding time comes the cabinet is wheeled in front of the cows for feeding purposes. This method involves a considerable amount of time and labor, and in practice can only be advocated where a number of cows are on test and everything possible is being done to cater to their appetites so that maximum feed consumption may lead to the greatest possible production of milk and butter fat.

2. Sometimes the feed boxes, instead of being kept in a cabinet, are stored on a shelf above the cows. This method is very similar to the one just mentioned, but is even more laborious.

3. Where a wide feeding alley is available, a row of covered boxes, each of which is large enough to hold the grain for one cow for a week or more, may be built along the wall. The feed is weighed up and placed in these bins and then measured out at feeding time with a scoop. This method induces the crowding up of the alleyways and makes it difficult to keep all the bins in good, clean condition; therefore it cannot be recommended.

4. A very satisfactory method is to have a feed wagon which is divided into several compartments, each containing a separate feed. To the wagon is attached a spring-balance scale, and the concentrates can be weighed out for each cow quite conveniently. Where an individual grain mixture is to be made up for each cow, this method is very suitable.

5. The best method in general herd practice is to make up a grain mixture which is known to be economical, and, from the feed wagon, weigh or measure out the amount required by each cow. Satisfactory feeding can be done in this way with a minimum amount of labor. Where this method is used there may at times be a few cows which will need something in addition to the general grain mixture, but this can

easily be provided. The additional material required in such cases will generally be an extra allowance of protein supplement, and a supply of this can be kept in the feed wagon, in a sack or bucket.

With each of these methods there should be a simple feed sheet showing what each cow is to receive. In this way accurate feeding will be done and the maximum economical production of milk will be obtained.

PREPARATION OF FEEDS

The preparation of feed, because of the influence it has on the palatability and utilization of the ration, is worthy of consideration. Additional preparation may at times render feeds more palatable and sometimes also more digestible; in such cases the more highly prepared feeds are advisable, provided that the cost of preparation is not so high as to neutralize the increased returns obtained as the result of the additional preparation.

Grinding.—Grinding and rolling are advisable with many grains. Such preparation generally renders the feed more palatable and reduces, to a considerable extent, the amount of grain which passes through the digestive tract of the animal unacted upon by the digestive juices. Grinding is to be preferred with such grains as corn and oats, while rolling is more advantageous in the case of barley, as finely ground barley, unless thoroughly mixed with bulky concentrates, tends to form pasty masses which are difficult to digest.

Corn is one of the most extensively fed cereal grains, and as there are more methods of preparing corn than other grains, attention to the cost of preparation of corn is desirable.

It will be noticed that there are differences of fair amount in the cost per hundred pounds of corn grain in the various corn preparations, and this must be taken into consideration

when determining which will be the most economical preparation to use.

TABLE XXVII

COST OF CORN PREPARATIONS

Preparation	Cost per Bushel		Cost per 100 Pounds	
	Preparing, Cents	Total, Cents	Feed, Dollars	Corn Grain, Dollars
Ear corn	....	50	.71	.89
Broken ear corn	2	52	.74	.93
Shelled corn	4	54	.96	.96
Ground corn	10	60	1.07	1.07
Corn-and-cob Meal	12	62	.89	1.11

Chopping.—In the case of dry roughages, chopping, cutting or shredding is sometimes practiced. It is not generally advisable, but where cows are being pushed for high production it may at times be advisable to cut some of the hay finely, moisten it and mix it with the grain ration to render it more bulky. Shredded corn stover, though not a good feed, can be given to dry stock, and what is not eaten can be used as bedding.

Soaking.—Grains are sometimes soaked in water and fed as a mash or slop, depending on what proportion of water is used. The main advantage to be obtained from this is in the increased amount of water which is consumed. In a few cases, for example with dried malt sprouts, soaking may improve the palatability of the feed and at the same time tend to prevent digestive disturbances.

There are two main cases, however, in which soaking can be advocated, namely, in the case of bran mashes, and with dried beet pulp. Bran mashes are used for correcting digestive disturbances, and for keeping the animals on feed; they are

one of the most valuable aids to the feeder. Dried beet pulp is sometimes mixed and fed with the grain ration, but this is not generally advisable. It should be soaked and fed with or in place of, silage and roots.

Cooking.—In certain European sections the cooking of grain for dairy cows is a common practice, but under American conditions it is not economical and should not be practiced.

CHAPTER XXIX

FEEDING ECONOMY

The main aim of the dairyman is profit, and considerable attention must, therefore, be paid to economy of production. Increased production without corresponding profits is not an incentive to improving the dairy industry. The factor of feed is the largest single item in the cost of milk production; in fact, it is greater than all other items combined, as it will on the average constitute about 60 per cent of the total cost of production. Consequently, the economy of feeding is the most important factor with which the dairyman has to contend. Intensive feeding leads to increased production; but a point can be reached above which the cost of milk production is so great that the increased production ensuing will not meet in returns the increased cost of feed. In commercial feeding, therefore, the best practice is to push the production of the cows up to this most profitable maximum and no further.

At various points, practices which lead to economy of production have been discussed; but a few principles which are applicable under all conditions are deserving of collective consideration.

INDIVIDUAL FEEDING

No matter whether a dairyman has one cow or a hundred, the individual cow is the ultimate unit to be considered. It is not enough to have half of the cows producing at a profit while part of this profit is used to pay for the keep of the other individuals in the herd. Every cow must be given a chance

to be profitable, and if she will not respond she should be disposed of. This necessitates attention to the individual requirements of the animals and the practice of feeding them according to their producing ability.

A very good example of this was obtained in the case of a herd in an Iowa cow-testing association. The herd consisted of ten cows. During one month in winter they were being fed a roughage ration of corn silage, timothy hay and corn stover. Each cow, no matter what her production—and they varied considerably in this respect—was given a daily allowance of 9 pounds of ear corn, 3 pounds of ground oats, 1 pound of linseed-oil meal and $1\frac{1}{2}$ pounds of cottonseed meal. The man in charge of the cow-testing association persuaded the owner to change his ration, and in the following month the cows received a roughage ration very similar to that mentioned and a grain mixture of 200 pounds of corn-and-cob meal, 100 pounds of ground oats, 200 pounds of cottonseed meal and 100 pounds of linseed-oil meal, each cow being allowed 1 pound of grain for each 3 pounds of milk produced.

The result was that the total production was increased from 5754 pounds of milk and 226 pounds of butter fat in the first month to 5697 pounds of milk and 254 pounds of fat in the second month. Of greater importance, however, are the following facts: in the first month the feed cost for the herd was $171, and the value of the milk and butter fat $168—resulting in a charge of $3 against the owner for milking his cows twice daily during that month; in the second month the feed cost had been reduced to $101, and the returns from the products increased to $191—leaving a net return over feed cost of $90 to the farmer, though the prices of feed and butter fat were the same in both months.

This increase in the net returns was due, to some extent, to the improvement in the nature of the grain ration, but mainly to the fact that the cows were being fed according to

production. This can be seen from the fact that the amount of grain comsumed in the first month was 4495 pounds, while that consumed in the second was 1899 pounds; the average grain ration had been reduced from $14\frac{1}{2}$ pounds to 6 pounds per cow daily.

LIBERAL FEEDING

The inherent capacity to produce, present in any animal worthy to be called a dairy cow, will manifest itself most strongly just after parturition. Many cows will produce well for a few weeks after calving, not because of the ration they are receiving, but in spite of it. It is continued heavy production throughout the lactation that leads to profits, and to induce this liberal feeding is essential.

The advantages of liberal feeding are clearly apparent in the case of an Iowa herd which was under the supervision of a cow-testing association for two years. This herd consisted of eleven cows. In the first season they were on pasture for six and one-half months, while in the second they were pastured for only five months. Their consumption of other feeds and their production is tabulated.

TABLE XXVIII

RECORD OF AN IOWA HERD FOR TWO YEARS

Year	Average Production		Average Feed Consumption			Average Feed Cost, Dollars	Average Returns Over Feed Cost, Dollars
	Milk, Pounds	Fat, Pounds	Grain, Pounds	Hay, Pounds	Silage, Pounds		
1	4845	237	906	2437	2240	62.40	77.16
2	7150	352	2102	2926	3503	104.00	150.36

In the second year the pasture season was shortened—a good idea under local conditions,—the hay allowance was increased by about 20 per cent and the silage by over 50 per cent. In addition the grain was more than doubled. The results obtained justified these changes, however, as not only was the average production increased from 237 pounds to 352 pounds of butter fat, but the returns over feed costs were increased from $77.16 per cow in the first year to $150.36 in the second year, even though the feed cost had been increased from $62.40 to $104.99 per cow.

Liberal feeding, controlled, of course, by the producing ability of the cows, practically doubled the returns over feed cost in this case; and the results indicate what the pursuance of rational feeding methods will accomplish.

USE OF HOME-GROWN FEEDS

The dairy cow must be looked on as the market for home-grown feeds. Through her can be marketed roughages that could not otherwise be disposed of, and she will return as large net returns from the farm-grown grains as will live stock of any other type. Though she is to be looked on as a market for the roughages of the farm, some effort should be made to meet the demands of the market.

Some succulence, in the form of silage, roots or other material, must be provided for winter, and silage or soiling crops are needed to supplement short, dry pastures in summer. Legume hays should be produced to supply the dry roughage the cow needs in winter, and she can utilize efficiently the corn, oats or barley grown for grain. The dairy farm should be self-supporting as far as these constituents of the ration are concerned.

THE PROTEIN SUPPLY

Though the dairy farm can furnish practically all of the constituents needed in the ration of the dairy cow, there is one group of feeds which, in general, have to be purchased. These are the concentrates of high protein content. The ration may be satisfactory in every other way, but for good producing cows an extra supply of protein will be necessary in addition to that contained in the group just mentioned. As a general rule, this extra supply of protein can only be provided by such factory by-products as cottonseed meal, linseed-oil meal, peanut meal or gluten feed.

The advantages of providing this extra feed can again be illustrated by the results obtained in an Iowa herd under the supervision of a cow-testing association. In the first year the cows had silage, mixed hay and pasture for roughage, and throughout the year the only grain allowance was 495 pounds of ground oats per cow. In the second year the silage was increased somewhat, while the hay allowance and the pasture season were reduced. The most marked change was in the grain ration, however, which was increased to an average of 1183 pounds per cow of a mixture of ground oats, cracked corn and bran, with an additional average allowance of 219 pounds of cottonseed meal. These are the average allowances, but in the second year each cow was fed according to production.

As a result of this the average production of the herd was increased from 304 pounds to 418 pounds of butter fat, and though the feed cost was increased from $53 to $83 per cow, the returns over feed cost increased from $129 per cow in the first year to $218 in the second.

CHOICE OF PROTEIN SUPPLEMENTS

As the main class of feeds that has to be purchased on the average dairy farm is the group of high protein supplements,

some consideration is necessary in their choice. The main point to which attention must be paid in the purchase of these concentrates is the cost of the digestible protein present, as this is the constituent for which these feeds are primarily purchased.

The digestible carbohydrate equivalent in the various concentrates is practically of uniform value, pound for pound, for feeding purposes, no matter what is the source of the feed. In calculating the cost of the digestible crude protein, a uniform value of 1 cent per pound can be placed on the digestible carbohydrate equivalent.

From the cost of 100 pounds of feed is subtracted the value of the digestible carbohydrate equivalent, and the difference, when divided by the percentage of digestible crude protein present and multiplied by 100, gives, in dollars and cents, the cost of 100 pounds of digestible crude protein in the given feed at the price stated.

The Appendix Table IV, on the cost per hundred pounds of digestible crude protein in some common concentrates at various prices has been prepared in this manner. In comparing feeds in this way a few important factors must be taken into consideration. The feeds under consideration should always be compared on the basis of the prices including freight charges as this frequently is an important item. Some feeds are not used as a source of protein, but for the furnishing of energy-providing materials, and so cannot be compared on this basis with the feeds of high protein content. Consequently it is not possible to compare such concentrates as corn-and-cob-meal and hominy feed with linseed-oil meal or cottonseed meal.

Granting that the feeds which provide protein at least cost should generally be purchased when protein is wanted, yet there are circumstances under which this rule must be somewhat modified. Where the rations contain no succulent feed such as silage, cottonseed meal should not be used, but linseed-oil

meal will fit in admirably under those conditions and so should be used rather than the cottonseed meal even if the cost of protein is somewhat greater. Then again, when the ration consists largely of corn silage and corn, it is not the best policy to use corn-gluten feed for the protein supplement, it being better to use feeds from some other source than the corn plant in order to give greater variety to the ration. With these limitations in mind, however, it is always well to purchase the protein supplements on the basis of the protein they contain.

CHAPTER XXX

DIGESTIVE DISTURBANCES

Dairy cattle, like other forms of live stock, are subject to disease; and though the general problem of derangements of health belongs to the field of the veterinarian, the man in charge of dairy cattle should be able to detect trouble when it arises and to call in a veterinary practitioner before it is too late.

Digestive disturbances are quite common among dairy cattle; and as the man in charge of the stock can usually control these by his feeding methods, attention to a few of them may not be out of place. Indigestion and similar troubles which pass under the same name in both calves and older animals have to be treated differently with the two classes of stock, and will therefore be given separate consideration.

CALVES

Calves, especially in the early stages of their development, are subject to a few common digestive troubles. These lead to general unthriftiness and, if not properly handled, to a fairly high rate of mortality. These derangements are amenable to treatment and should be recognized by the man in charge. White scours will not be considered, as it is not of digestive origin, though some of its chief manifestations are in the digestive tract.

Prevention is undoubtedly the best treatment for calf troubles, and with careful feeding and management and

reasonable sanitary precautions considerably less trouble is experienced with the more common digestive disturbances of calves.

Constipation.—The young calf requires the colostrum, or first milk, of its dam to assist in getting the intestinal tract in good working order. If the calf does not get the colostrum, he may become constipated. Improper feeding, such as lack of sufficient roughage, in older calves may also bring about constipation. One of the safest treatments for constipation is to administer castor oil in doses of 1 to 3 ounces, depending on the size and age of the calf. The young calf should be watched carefully until it is certain that the bowels are in working order.

Indigestion.—In the cases of calves, indigestion may be due to one or more of a variety of causes. Among the more common of these are constipation, overfeeding, irregularity in the time of feeding, carelessness in the amount and quality as well as in the temperature of the milk fed, the feeding of dirty milk or other feeds that are in bad condition, too rapid changes in the amount or nature of the feed, or chills brought on by draughts or by cold, damp floors. The cause of the trouble should be immediately located and remedied, and in addition the feed should be cut down and castor oil administered. Where abnormal fermentations, due to dirty milk, are the cause of indigestion, the administration of limewater frequently aids in bringing relief.

Bloat.—This form of indigestion is generally due to abnormal fermentations in the stomach, brought about by dirty milk, or to the calves sucking each other and thus drawing air into their stomachs. The swallowing of the foam sometimes found on separated milk is also a cause, and any of the causes of indigestion may ultimately result in bloat. Castor oil should be administered after the elimination of the cause, and the feed allowance should be reduced. Sometimes a

teaspoonful of ground Jamaica ginger given in hot water will be valuable in giving relief if the bloat is severe enough to cause colic. The ginger also has a tonic effect on the stomach and aids in rapid recovery. A drench of 10 cubic centimeters of commercial formalin in half a pint of water is also a convenient remedy for bloat.

Common Scours.—Though easily prevented by proper care and feeding, common scours are all too prevalent among dairy calves. Any of the causes given for the digestive disturbances already mentioned may ultimately result in scours, and another cause is the feeding to young calves of milk that is too rich in butter fat. When calves are comfortably housed and properly fed and cared for, there should be little trouble from common scours.

As ordinary scours is a simple digestive derangement, the treatment given should be such as will bring the digestion back to normal. Remove the cause of the trouble, and at the same time cut the milk ration down by at least one-half. This relieves the digestive system, and it can be assisted in freeing itself of obnoxious materials by the administration of 1 to 3 ounces of castor oil.

Treating with formalin also gives beneficial results. A stock solution of 1 part of commercial formalin to 31 parts of water is made, and a teaspoonful of this mixture is added to each pound of milk fed. The formalin acts as a disinfectant, destroying the putrefactive organisms which induce the scours. Another satisfactory method of control is to mix 50 grains of salol, $1\frac{1}{2}$ drams of bismuth subnitrate, and 2 drams of sodium bicarbonate, and make into five powders. One of the powders is given in milk every six hours.

When the trouble is under control, the calf should be brought slowly back on to full feed. Where the calf is very weak and will not drink, it can be kept nourished by the occasional administration of an egg. The shell of the egg is

cracked, and the egg, shell and all, put well back in the calf's mouth. If the calf's mouth is kept closed he will break and swallow the egg.

MATURE STOCK

The number of digestive disturbances of mature stock which are commonly met with are quite limited. The main problem is keeping the cows on feed. There are but three digestive troubles which need be mentioned.

Indigestion.—There are many causes which lead to indigestion, but the more common contributory causes are overfeeding, spoiled feed, and sudden changes in the ration. When indigestion occurs it will be noted that the cow is dull and lacks appetite, while the feces are very dry and small in amount or almost entirely absent. In cases, however, where the causal factor is some irritant substance, purging may occur.

Treatment consists of cutting down the ration and feeding bran mashes in place of grain. Sometimes this is all that is necessary, but frequently the administration of purgatives is essential. Useful purgatives, to be given as drenches, are the following: 1 to $1\frac{1}{2}$ pounds of Epsom salts in 2 quarts of warm water; 1 pound of Epsom salts and 1 pound of molasses in 2 quarts of warm water; or 1 to $1\frac{1}{2}$ quarts of raw linseed oil. The last is the mildest in action. Where Epsom salts are given, it is well to try to induce the cow to drink considerable quantities of slightly warmed water. This hastens the action of the purgative. When the action of the purgative is apparent and the appetite of the cow is returning, she should be brought back to full feed slowly, the grain ration being limited for a time and bran mashes fed.

Bloat.—The accumulation in the rumen of gas liberated through the influence of bacterial action on soluble food constituents, especially carbohydrates, leads to bloat. It occurs

most frequently when animals are pastured on clover, alfalfa or other legumes, and is especially prevalent when these crops are young and succulent. Other young crops will also bring about this condition. Bloat from this cause can be prevented to a considerable extent by having the animals fairly well filled before they are turned out to pasture, and the pasture should not be wet when the animals go on. A good feed of hay before the animals are turned out is quite satisfactory as a preventive measure in many cases; but where there is danger of bloat on pasture the animals should be allowed to remain out only a short time daily for the first few days. As they become accustomed to it the length of time on pasture can be gradually increased.

When soiling is being fed in the barn, bloat is rare; but it does occasionally occur under those conditions. Overfeeding on any feed, and digestive disturbances accompanied by excessive fermentation will also result in bloat.

There is a characteristic swelling of the left flank in the case of bloat, and this may extend up to the back bone; in some cases the distended rumen may appear higher than the level of the back. The animal is restless and apparently in distress. In advanced cases breathing is labored and the animal may stagger and fall. Death may occur from suffocation due to the pressure of the rumen on the diaphragm interfering with respiration. Rupture of the stomach may also occur.

There are many methods of treatment pursued in cases of bloat, or tympanitis, and a few of the more common ones are as follows:

1. The bloated animal is kept moving. This leads to movement of the rumen and aids in the liberation of gas. In slight attacks this is occasionally all the treatment that is necessary.

2. A stick—a piece of a fork handle is satisfactory—is put in the mouth of the animal, as is a bit, and the ends of it are

tied to the horns of the animal or to a halter. The animal chews on the stick, and in the process gas is liberated and the tympanitis relieved. This process is aided by standing the animal with the fore feet at a higher level than the hind ones.

3. The introduction of a rubber tube through the mouth to the stomach sometimes gives relief. This, however, is occasionally difficult to do and it is not satisfactory in all cases.

4. A number of drenches are recommended for bloat. Two that are satisfactory and easily prepared are: 3 ounces of turpentine in 1 pint of raw linseed oil; half an ounce of formalin in 1 quart of water. Either of these will bring relief fairly readily, but they will be aided in their action by tying a stick in the mouth of the animal.

When the bloating has subsided it is frequently advisable to give the animal a purgative to clean out the digestive tract and prevent the recurrence of the trouble. A suitable drench is 1 pound of Epsom salts and $1\frac{1}{2}$ ounces of ground Jamaica ginger in 2 quarts of warm water. The Epsom salts remove the material that has been causing trouble and the ginger has a tonic effect.

5. When the bloat is very severe and there is danger of the animal collapsing before any of the methods mentioned could be effective, piercing with a trocar and canula must be resorted to. The point at which the trocar should be inserted is equidistant between the last rib, the hip bone and the lumbar vertebræ. The trocar should be pushed downward, inward and forward, and as it is withdrawn the canula should be left in place to allow the gas to escape as it forms. When the gas ceases to form the canula may be withdrawn, but the animal must be watched to see that the use of the trocar is not again necessary. It is usually best to cork the canula at intervals, as the formation of gas can be easily detected when the cork is withdrawn. The trocar and canula should be disinfected before use.

The treatment of bloat is simple; but occasionally animals will be found which bloat habitually with little or no provocation. Such individuals should be disposed of.

Impaction.—The rumen of the cow has a large capacity, but at times when it is not functioning properly a large amount of feed may become lodged there and cause distention. This condition, known as impaction, is easily distinguished from bloat. In the case of bloat, if the enlargement be pressed in, it will at once return to its original position when released; but in the case of impaction some little time will be required for this to take place.

Impaction is largely induced by overfeeding, especially of dry feeds such as hays and grains. The first step in treatment is consequently to stop feeding. Then when the excess of material in the rumen has started to pass on a purgative should be given. Any of those mentioned are good, and it is well also to give ginger. The return to full feed should be gradual. This simple treatment is generally effective, but in some cases veterinary assistance is needed.

PART VI

APPENDICES

APPENDIX I

DIGESTIBLE NUTRIENTS IN FEEDS

The content of digestible nutrients given here for the various feeds is taken by special permission from the extensive data in Appendix Table III of the seventeenth edition of " Feeds and Feeding " by W. A. Henry and F. B. Morrison. Only feeds that are of special interest in the feeding of dairy cattle and a few that are of note on some other accounts are included. The method of using this table is outlined in Chapter VIII.

APPENDIX TABLE I

Digestible Nutrients in Feeds

Feed	Total Dry Matter, Per Cent	Digestible Nutrients: Crude Protein, Per Cent	Carbohydrate, Per Cent	Fat, Per Cent	Total, Per Cent
Succulent Roughages					
Silage:					
Corn, mature	26.3	1.1	15.0	0.7	17.7
Corn, immature	21.0	1.0	11.4	0.4	12.3
Corn stover	19.6	0.5	9.9	0.4	11.3
Corn cannery refuse	16.7	0.1	4.9	0.1	5.2
Sorghum	22.8	0.6	11.6	0.5	13.3
Alfalfa	24.6	1.2	7.8	0.6	10.4
Clover	27.8	1.3	9.5	0.5	11.9
Soybean	27.1	2.6	11.0	0.7	15.2
Corn and Soybean	24.7	1.6	13.8	0.8	17.2
Green Forage:					
Alfalfa	25.3	3.3	10.4	0.4	14.6
Clover, red	26.2	2.7	13.0	0.6	17.1
Clover, Alsike	24.3	2.7	11.8	0.4	15.4
Sweet clover	24.4	3.3	10.3	0.3	14.3
Peas	16.6	2.9	7.1	0.3	10.7
Cowpeas	16.3	2.3	8.0	0.3	11.0
Soybeans	23.6	3.2	10.2	0.5	14.5
Corn fodder	21.9	1.0	12.8	0.4	14.7
Sweet-corn stover	21.5	1.0	13.1	0.3	14.8
Oats	26.1	2.3	11.8	0.8	15.9
Rye	21.3	2.1	12.2	0.5	15.4
Millet, common	27.6	1.9	14.8	0.6	18.1
Sorghum	24.9	0.7	14.1	0.6	16.2
Oats and peas	22.6	2.4	10.6	0.6	14.4
Bluegrass	31.6	2.3	14.8	0.6	18.5
Roots, Tubers, etc.					
Sugar beets	16.4	1.2	12.6	0.1	14.0
Mangels	9.4	0.8	6.4	0.1	7.4
Turnips	9.5	1.0	6.0	0.2	7.4
Rutabagas	10.9	1.0	7.7	0.3	9.4

APPENDIX TABLE I—*Continued*

Feed	Total Dry Matter, Per Cent	Digestible Nutrients			
		Crude Protein, Per Cent	Carbo-hydrate, Per Cent	Fat, Per Cent	Total, Per Cent
SUCCULENT ROUGHAGES *Continued*					
Roots, Tubers, etc.—Continued					
Beet pulp	91.8	4.6	65.2	0.8	71.6
Potatoes	21.2	1.1	15.8	0.1	17.1
Pumpkins	8.3	1.1	4.5	0.5	6.7
DRY ROUGHAGES					
Alfalfa	91.4	10.6	39.0	0.9	51.6
Clover, red	87.1	7.6	39.3	1.8	50.9
Clover, Alsike	87.7	7.9	36.9	1.1	47.3
Sweet clover	91.4	10.9	38.2	0.7	50.7
Pea	88.9	12.2	40.1	1.9	56.6
Cowpea	90.3	13.1	33.7	1.0	49.0
Soybean	91.4	11.7	39.2	1.2	53.6
Corn fodder	81.7	3.0	47.3	1.5	53.7
Corn stover	81.0	2.1	42.4	0.7	46.1
Oat straw	88.5	1.0	42.6	0.9	45.6
Timothy	88.4	3.0	42.8	1.2	48.5
Millet, common	85.7	5.0	46.0	1.8	55.0
Sudan grass	91.6	3.3	53.4	0.9	58.7
Sorghum fodder	90.3	2.8	44.8	2.0	52.1
Oat and pea	83.4	8.3	37.1	1.5	48.8
CONCENTRATES					
Corn, shelled	89.5	7.5	67.8	4.6	84.7
Corn meal	88.7	6.9	69.0	3.5	83.8
Corn-and-cob meal	89.6	6.1	63.7	3.7	78.1
Hominy feed	89.9	7.0	61.2	7.3	84.6
Germ-oil meal	91.1	16.5	42.6	10.4	82.5
Corn bran	90.0	5.8	56.9	4.6	73.1
Gluten meal	90.9	30.2	43.9	4.4	84.0
Gluten feed	91.3	21.6	51.9	3.2	80.7
Corn distillers' grains	93.4	22.4	40.4	11.6	88.9
Ground oats	89.2	9.4	51.4	4.1	70.0

APPENDIX TABLE I—*Continued*

Feed	Total Dry Matter, Per Cent	Digestible Nutrients: Crude Protein, Per Cent	Carbohydrate, Per Cent	Fat, Per Cent	Total, Per Cent
Concentrates—*Continued*					
Wheat	89.8	9.2	67.5	1.5	80.1
Wheat bran	89.0	12.5	41.6	3.0	60.9
Wheat middlings	89.5	13.4	46.2	4.3	69.3
Flour-wheat middlings	89.3	15.7	52.8	4.3	78.2
Red Dog flour	88.9	14.8	56.5	3.5	79.2
Barley	90.7	9.0	66.8	1.6	79.4
Malt sprouts	92.4	20.3	47.4	1.3	70.6
Brewers' grains	92.5	21.5	30.5	6.1	65.7
Rye	90.6	9.9	68.4	1.2	81.0
Rye distillers' grains	92.8	13.6	38.0	6.6	66.4
Rice	90.4	4.7	64.6	1.7	73.1
Kafir	88.2	9.0	65.8	2.3	80.0
Milo	89.3	8.7	66.2	2.2	79.9
Peas	90.8	19.0	55.8	0.6	76.2
Cowpeas	88.4	19.4	54.5	1.1	76.4
Soybeans	90.1	30.7	22.8	14.4	85.9
Soybean meal	88.2	38.1	33.0	5.0	83.2
Peanut meal	89.3	42.8	20.4	7.2	79.4
Peanut feed	94.4	20.2	16.0	10.0	58.7
Cottonseed meal	92.5	37.0	21.8	8.6	78.2
Cold-pressed cottonseed cake	92.1	21.1	33.2	7.4	70.0
Flax seed	90.8	20.6	17.0	29.0	102.8
Linseed meal, O. P.	90.9	30.2	32.6	6.7	77.9
Linseed meal, N. P.	90.4	31.7	37.9	2.8	75.9
Coconut meal	90.4	18.8	42.0	8.1	79.0
Palmnut meal	89.6	12.4	45.8	9.5	79.6
Buckwheat	87.9	8.1	49.7	2.5	63.4
Molasses, cane	74.2	1.0	58.2	0.0	59.2
Dairy Products					
Whole milk	13.6	3.3	4.9	4.3	17.9
Skim milk	9.9	3.6	5.1	0.2	9.1
Buttermilk	9.4	3.4	4.9	0.1	8.4
Whey	6.6	0.8	4.7	0.3	6.2

APPENDIX II

A FEEDING STANDARD FOR DAIRY COWS

All present-day feeding standards are modifications of the original Wolff-Lehmann Standard. The one presented here has been prepared by Morrison and is taken by express permission from the tables in the eighteenth edition of "Feeds and Feeding," by Henry and Morrison.

It has one great advantage in that only two units are used, digestible crude protein and total digestible nutrients. In addition, a minimum and maximum is given in each case. The maxima are for use with high producing cows and the minima for low producers. A variation in the relative amounts of protein and total nutrients is also provided. This is due to the fact that, in general, protein is more expensive than other nutrients and so should not be fed to excess, while at other times feeds of high protein content are relatively low in price and so can be fed in greater quantities. In certain sections also, especially in the south and in the western alfalfa regions, the feeds of relatively high protein content are generally cheap. The method of using this standard is explained in Chapter VIII.

APPENDIX TABLE II

A Feeding Standard for Dairy Cows

	Digestible Crude Protein, Pounds	Total Digestible Nutrients, Pounds
Dairy Cows:		
For maintenance of 1000-lb. cow..........	0.700	7.925
To allowance for maintenance add:		
For each pound of 2.5 per cent milk.......	0.045–0.053	0.230–0.256
For each pound of 3.0 per cent milk.......	0.047–0.057	0.257–0.286
For each pound of 3.5 per cent milk.......	0.049–0.061	0.284–0.316
For each pound of 4.0 per cent milk.......	0.054–0.065	0.311–0.346
For each pound of 4.5 per cent milk.......	0.057–0.069	0.338–0.376
For each pound of 5.0 per cent milk.......	0.060–0.073	0.362–0.402
For each pound of 5.5 per cent milk.......	0.064–0.077	0.385–0.428
For each pound of 6.0 per cent milk.......	0.067–0.081	0.409–0.454
For each pound of 6.5 per cent milk.......	0.072–0.085	0.434–0.482
For each pound of 7.0 per cent milk.......	0.074–0.089	0.454–0.505

APPENDIX III

MINERAL ELEMENTS IN FEEDS

The mineral or ash content of feeds has an important bearing on their value, especially for the growth of bone and for milk production. Little work on this problem has really been accomplished. The figures in the accompanying table are selected from "Mineral and Organic Analyses of Foods," published as Bulletin 255 of the Ohio Agricultural Experiment Station, by E. B. Forbes and others in 1913.

Some of the important facts to note are the amount of total ash, and the amounts of calcium and phosphorus which are used in bone-building. The excess of base and the excess of acid are also worthy of attention. All other data are given on the percentage basis; but the excess of base is expressed in the number of cubic centimeters of normal acid solution that is required to neutralize the excess base in 100 grams of the dried material. The excess acid is likewise expressed in terms of the number of cubic centimeters of normal solution of alkali required to neutralize the excess acid in 100 grams of dried material.

It may be noted that all of the concentrates studied, with the exception of wheat bran, linseed-oil meal and the legumes, contain an excess of acid, while all of the roughages listed are basic in character.

APPENDIX TABLE III

Mineral Elements in the Dry Matter of Some Common Feeds

Feeds	Total Ash, Per Cent	Potassium, Per Cent	Sodium, Per Cent	Calcium, Per Cent	Magnesium, Per Cent	Sulphur, Per Cent	Chlorine, Per Cent	Phosphorus, Per Cent	Excess of Base	Excess of Acid
Concentrates										
Corn	1.410	.396	.030	.014	.126	.171	.073	.303	......	9.88
Gluten feed	3.460	.272	.461	.268	.239	.636	.098	.580	......	20.48
Wheat	1.866	.590	.035	.056	.142	.224	.095	.425	......	13.01
Red Dog flour	4.151	.425	.733	.134	.324	.285	.156	.928	......	6.07
Wheat bran	6.729	1.464	.223	.139	.590	.297	1.000	1.233	1.54	
Oats	3.709	.460	.184	.112	.130	.214	.077	.434	......	7.54
Kaffir corn	1.339	.288	.066	.013	.142	.186	.117	.271	......	9.91
Cottonseed meal	7.629	1.811	.283	.291	.599	.536	.042	1.470	......	7.73
Linseed-oil meal	6.463	1.224	.282	.403	.544	.455	.095	.786	27.29	
Cowpeas	4.302	1.636	.189	.117	.243	.280	.047	.532	22.59	
Soybeans	5.532	2.095	.380	.230	.244	.444	.025	.640	31.24	
Dry Roughages										
Corn stover	7.007	1.847	.065	.507	.092	.187	.308	.102	55.90	
Wheat straw	3.650	.842	.237	.217	.063	.159	.209	.038	29.56	
Millet hay	5.887	1.338	.099	.326	.262	.159	1.230	.173	51.65	
Timothy hay	3.470	.613	.345	.192	.111	.162	.199	.123	25.74	
Alfalfa hay	6.890	.832	.489	1.130	.400	.298	.161	.238	93.15	
Clover hay	7.313	1.840	.067	1.236	.292	.190	.259	.183	104.51	
Cowpea hay	12.030	.873	.722	2.029	1.006	.352	.167	.283	199.96	
Soybean hay	8.580	1.774	.145	1.378	.692	.259	.084	.237	143.41	
Succulent Roughages										
Bluegrass	5.250	1.405	.141	.336	.240	.334	.234	.242	35.32	
Mangels	10.270	3.870	.714	.131	.358	.224	1.380	.260	96.09	
Beet pulp	3.216	.347	.185	.729	.283	.138	.048	.069	62.10	

APPENDIX IV

RELATIVE ECONOMY OF PROTEIN SUPPLEMENTS

A METHOD of determining the relative cost of 100 pounds of protein in the various protein supplements has been outlined in Chapter XXIX. For convenient reference the protein costs have been worked out for a number of concentrates and are given in the table here. When this table is used, its limitations, which have already been mentioned, should be remembered.

APPENDIX TABLE IV

Cost per Hundred Pounds of Digestible Crude Protein in Some Common Concentrates at Various Prices

Cost per Ton	$24	$26	$28	$30	$32	$34	$36	$38	$40	$42	$44	$46	$48	$50	$52	$54	$56
Feeds	Cost per Hundred Pounds Digestible Crude Protein in Dollars and Cents																
Corn, whole	5.57	6.91	8.24	9.57	10.91	12.24	13.57	14.91	16.24	17.57	18.91	20.24	21.57	22.91	24.24	25.57	26.91
Corn meal	6.25	7.70	9.14	10.59	12.04	13.49	14.94	16.39	17.84	19.29	20.74	22.19	23.64	25.09	26.54	27.99	29.43
Corn-and-cob meal	7.87	9.51	11.15	12.79	14.43	16.07	17.70	19.34	20.98	22.29	24.26	25.90	27.54	29.18	30.82	32.46	34.10
Hominy feed	6.06	7.49	8.91	10.34	11.77	13.20	14.63	16.06	17.49	18.91	20.34	21.77	23.20	24.63	26.06	27.49	28.91
Gluten feed	2.82	3.28	3.75	4.21	4.67	5.13	5.60	6.06	6.52	6.99	7.45	7.91	8.38	8.84	9.30	9.72	10.23
Gluten meal	2.19	2.52	2.85	3.19	3.52	3.85	4.18	4.51	4.84	5.17	5.50	5.83	6.17	6.50	6.83	7.16	7.49
Germ-oil meal	3.27	3.88	4.48	5.09	5.70	6.30	6.91	7.52	8.12	8.73	9.33	9.94	10.55	11.15	11.76	12.36	12.97
Red Dog flour	3.76	4.43	5.11	5.78	6.46	7.14	7.81	8.49	9.16	9.84	10.51	11.19	11.86	12.54	13.22	13.89	14.57
Wheat shorts	4.78	5.53	6.28	7.02	7.77	8.51	9.26	10.01	10.75	11.50	12.25	12.99	13.74	14.49	15.23	15.98	16.72
Wheat bran	5.73	6.53	7.33	8.13	8.93	9.73	10.53	11.33	12.13	12.93	13.73	14.53	15.33	16.13	16.93	17.73	18.53
Oats, whole	6.11	7.14	8.18	9.21	10.24	11.27	12.30	13.33	14.36	15.39	16.42	17.46	18.48	19.52	20.55	21.58	22.61
Oats, ground	6.32	7.38	8.45	9.51	10.57	11.64	12.70	13.77	14.83	15.89	16.96	18.02	19.09	20.15	21.21	22.28	23.34
Barley	5.51	6.62	7.73	8.84	9.96	11.07	12.18	13.29	14.40	15.51	16.62	17.73	18.84	19.96	21.07	22.18	23.29
Cottonseed meal	2.13	2.40	2.67	2.94	3.21	3.48	3.75	4.02	4.29	4.56	4.83	5.10	5.37	5.64	5.91	6.18	6.45
Cold-pressed cottonseed cake	3.33	3.80	4.27	4.75	5.22	5.70	6.17	6.64	7.12	7.59	8.07	8.54	9.01	9.49	9.96	10.44	10.91
Linseed-oil meal, O. P.	2.39	2.73	3.06	3.39	3.72	4.05	4.38	4.71	5.04	5.37	5.71	6.04	6.37	6.70	7.03	7.36	7.69
Cowpea	3.25	3.76	4.28	4.79	5.31	5.82	6.34	6.86	7.37	7.89	8.40	8.92	9.43	9.95	10.46	10.98	11.49
Field pea	3.31	3.83	4.36	4.88	5.41	5.94	6.46	6.99	7.52	8.04	8.57	9.09	9.62	10.15	10.66	11.20	11.73
Soybean	2.11	2.44	2.76	3.09	3.41	3.74	4.07	4.39	4.72	5.04	5.37	5.69	6.02	6.35	6.67	7.00	7.32

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